COLORADO RIVER INVESTIGATIONS XI
July - August, 1992

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Northern Arizona University

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Submitted to
Robert S. Chandler, Superintendent
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Grand Canyon, Arizona

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INTRODUCTION

This report presents results of a graduate course on the geology, hydrology, and biology of the Grand Canyon offered through Northern Arizona University with support and cooperation from the National Science Foundation and the National Park Service, Grand Canyon National Park. Conducted during the months of July and August, 1992, this program involved classroom instruction, short field trips, and an eleven day river trip on the Colorado River through the Grand Canyon. During that trip, each student participated in a research project under the supervision of Stanley Beus, Jim David, Frank Lojko, and Larry Stevens. The data collected and the conclusions presented contribute to several ongoing studies and questions of concern to the National Park Service in the management of the resources in the Grand Canyon.

CHAPTER 1

BEACH PROFILE SURVEYS WITHIN THE COLORADO RIVER CORRIDOR OF THE GRAND CANYON, 1992

Christine Donovan, Viki Hughes, David Komoto
James Mathews, Charles Rey, David Susuras
David Thompson, Kelcy Thompson, William West

Introduction

Alluvial sand deposits along the banks of the Colorado River below Lee's Ferry are constantly being used by river travelers seeking comfortable campsites. These beaches contribute to the overall recreational enjoyment of boaters, rafters and hikers. The riparian zone here also supports a multitude of plants and animals, some of which are indigenous only to this area. Because of the fluctuating water releases from the Glen Canyon Dam since 1963, beach alteration has been occurring. The National Environmental Policy Act of 1989 initiated an environmental impact study to evaluate the concern that these beach resources were being lost to erosion.

Beach surveying was conducted by a team of science educators from across the United States. Profiles of these sand deposits were determined by transit surveys from benchmarks and cross-sections which had been previously established from ten years of preceding studies. A total of 31 cross-sections were surveyed on 16 beaches. The profiles were then compounded with data from annual surveys accumulated since 1982 in order to determine topographic changes on these beaches.

Findings from this research will be submitted to the Grand Canyon National Park Service and the Bureau of Reclamation so their management agencies might better understand the alluvial sand alterations at these beaches.

Methods

Previously established benchmarks were located (one to three per beach). Instrument stations were set (as per historical data) from which horizontal sight readings were taken, based on topography, following historical profiles. Recordings of this cross-sectional data were used to generate new beach profiles which were then compared and contrasted with past profiles taken at the same geographic positions.

A. Required Materials in the field

1. 1 survey transit with box
2. 1 tripod
3. 1 100 ft. tape
4. 1 200 ft. tape
5. 2 red and white steel surveying pins
6. 1 25 ft. retractable survey rod
7. 2 hand lens
8. 1 roll of orange flagging tape
9. 1 metal clipboard
10. machete
11. shovel
12. can of WD-40
13. chalkboard
14. chalk
15. pencils
16. pencil sharpener
17. eraser
18. umbrella
19. data sheets
20. screwdriver
21. file folders (one per beach)
22. beach profile location sheets
23. cross-section data sheets
24. camera
25. black and white film
26. Brunton compass

B. Required Materials in the lab

1. data sheets
2. calculator
3. 3-ring binder
4. graph paper
5. computer (MAC Cricket graph)
6. 3-hole paper punch

C. Procedures

Legend: BS (numbered) = Benchmarks or base stations
CS (numbered) = Cross-section
HI = Height of instrument (transit barrel)
Instrument station, once located, is referred to as CS

1. Locate all BS's as noted in historical data records (refer to photo history as needed). Tie flag tape to point of BS nail to increase visibility.
2. Stretch measuring tape between BS's; mark instrument stations using red and white survey pins along this line (as per historical data). Tie flag tape to pins to increase visibility.
3. Set transit on instrument station (hereafter referred to as CS).
4. Level the transit
5. Read vernier scale and determine the angle of direction (as per historical data).
6. Take and record rod reading from the CS onto (toward) whichever BS is to be used for elevation data.
7. Take and record HI.
8. Orient transit barrel along the designated profile direction (refer to historical data).
9. Take and record rod readings along this profile, from CS to water's edge. Readings are taken at arbitrarily selected positions based on topography (i.e. change in slope or change in composition of beach).
10. Take and record rod readings from the same CS onto (toward) any other available BS.
11. Repeat steps 3 through 10 with the transit set on successive cross-sections.
12. See addendum 1-1 for additional procedural recommendations.

Note: If horizontal sight readings cannot be taken due to extreme slope of beaches or excessive non-removeable vegetation, adjustments must be made in the angle of the transit barrel.
If there is extreme downward slope of beach in relation to BS (resulting in insufficient height of rod,) adjust the barrel downward. Record the change in barrel angle* and take rod reading.
If there is extreme upward slope of beach in relation to BS, adjust barrel upward so as to fix on 0.00 reading of rod height, and record change of barrel angle required to achieve this reading.

* (tan 0) (horizontal distance) = vertical distance (where 0= theta)

(Photo note: Photograph each new benchmark from two angles, incorporating landmark features of the beach. Photograph each cross-section if there is some obvious change from previous year's photos).

* Table 2-1. Beach Profiles Surveyed

River Mile	Beach Name	1974	75	80	82	83	84	85	86	87	88	89	90	91	92
L 18.2	Upper 18 Mile Wash		2				2	2	2	2	2	1			
L 19.3	19 Mile Wash (gone)		2	1		2		2	2						
L 19.8	19.8 Mile											2	2		2
L 31.6	South Canyon													2	2
L 34.7	Nautiloid Canyon	2	2			2	2	2	2	2	2	2	2	2	2
R 53.0	Lower Nankoweap	3	3	1		1	3	2	1	2				1	
R 58.1	Awatubi						1		1	1	1	1	1	1	1
R 61.8	Mouth of the LCR	1		1		1	1	1	2	1			1	1	1
L 65.5	Tanner Mine	2		2		2	2	2	2						
R 72.2	Unkar Indian Village (gone)	1	1	3		2	1								
L 75.0	Nevills Rapid (new 1984)						2	2	2	2	1	1	2	1	2
L 81.1	Grapevine	2		2		2	1	2	2	2	2	2	2	2	2
L 87.1	Lower Suspension Bridge		2	1				1							
L 93.2	Upper Granite Rapid	2		1		2	2	2	2	2	2	2		2	2
R109.4	109 Mile (gone)	2				1	2								
R112.2	Wallenberg Canyon (gone)	1		1		1	1								
R120.1	Blacktail Canyon	2		2	1	2	2	2	2	2	2	2	2	2	2
R122.0	122 Mile Beach (new 1985)							2	2	2	2	2			2
L122.8	Forester Canyon (new 1983)					3	3	3	3	2	3	1	2	2	2
L124.4	Upper 124 1/2 Canyon (gone)	2			1	1									
R131.0	Bedrock Rapid	2		2		2	2	2	2	2	2	2	2	2	
L136.6	Poncho's Kitchen (new 1988)										2	2	2	2	2
L151.6	The Ledges (gone)	2	2			1	2	2		1					
L166.5	Upper National		2	1		1	2	2		2	2	1	2		
L166.5	Lower National (new 1985)							2	5	5	5	5	5	5	5
R180.9	Lower Lava Falls	2		2		2	2	2	2	2	2				
L190.2	190 Mile		1	1			1	1	1	1	1		1		1
L193.9	194 Mile Beach (new 1987)									3	3	3		3	3
L208.8	Granite Park	2	2	2	1	2	2	2	2	2	2	2	2	1	
R220.0	220 Mile Beach (new 1985)							2	2	2	2				2

* 1974, 75 data from Howard (1975)
1980 data from Dolan (1981)
1982 to 1992 data from Beus and others (1992)

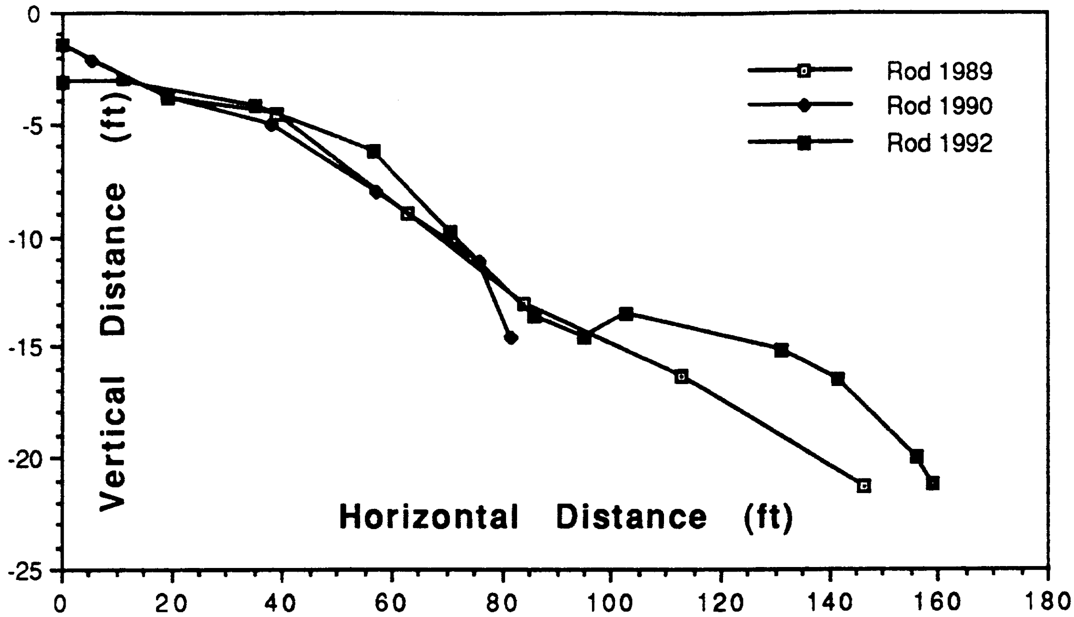


Figure 1. L 19.8 CS2

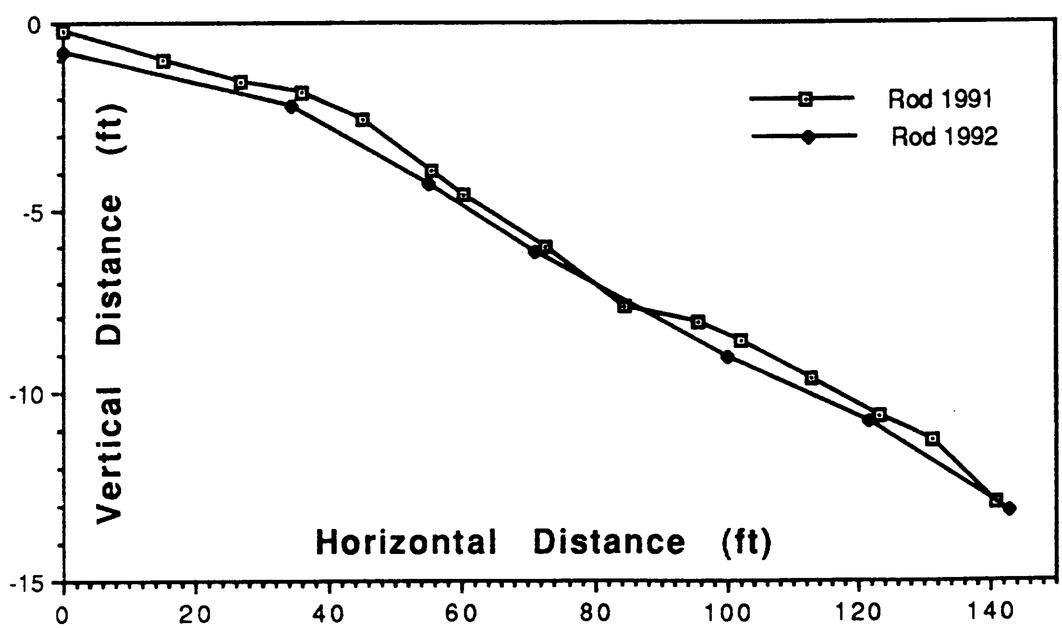


Figure 2. R 31.6 CS1 South Canyon Beach

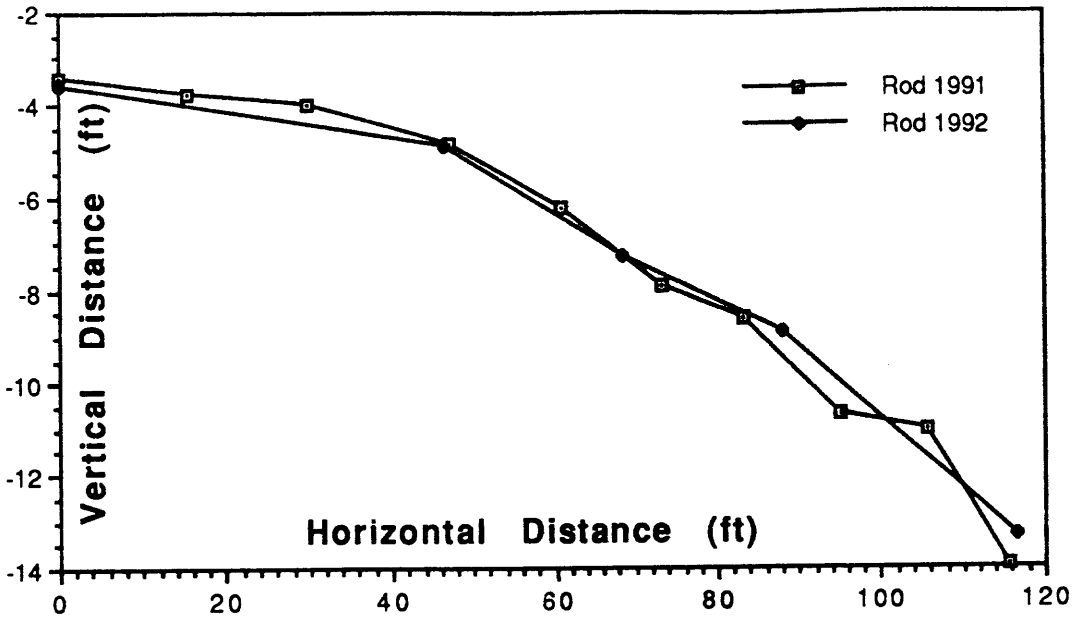


Figure 3. R 31.6 CS2 South Canyon Beach

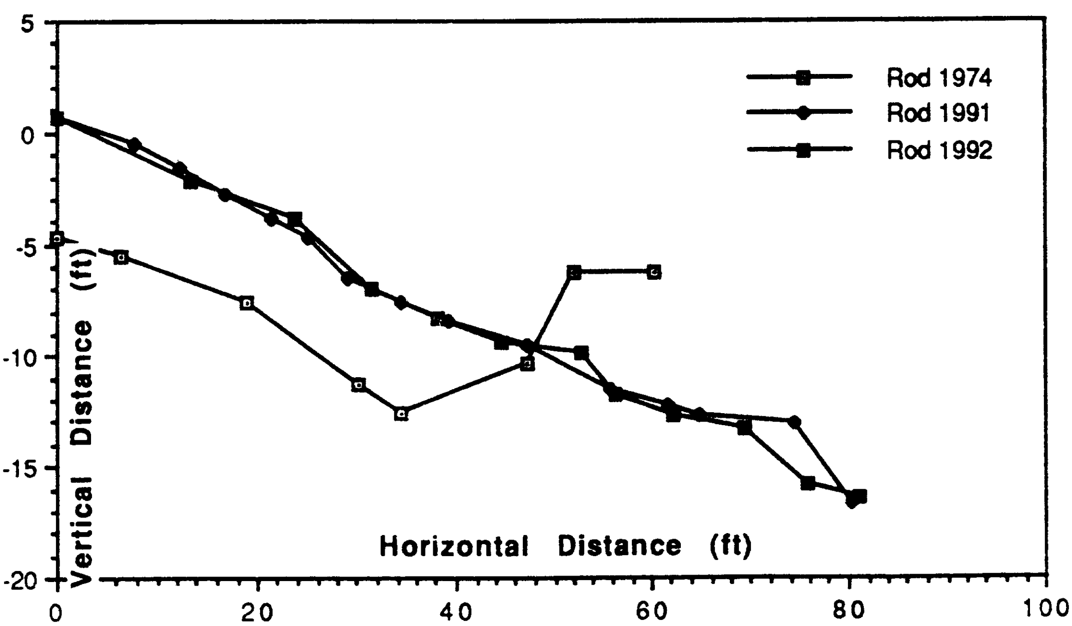


Figure 4. L 34.7 CS2 Nautiloid Canyon

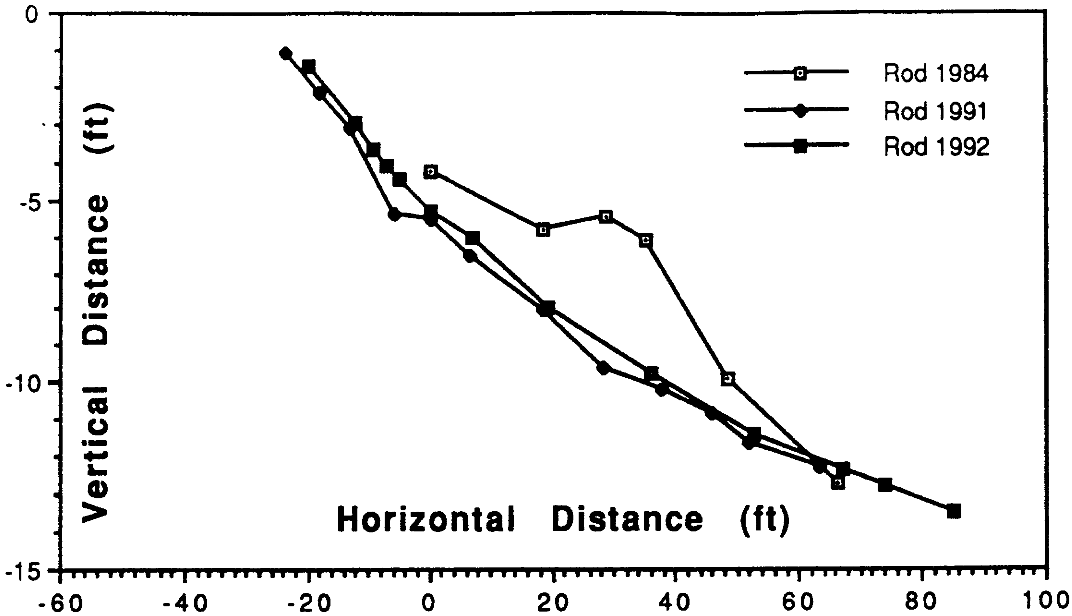


Figure 5. R 58.1 CS1 Awatubi beach

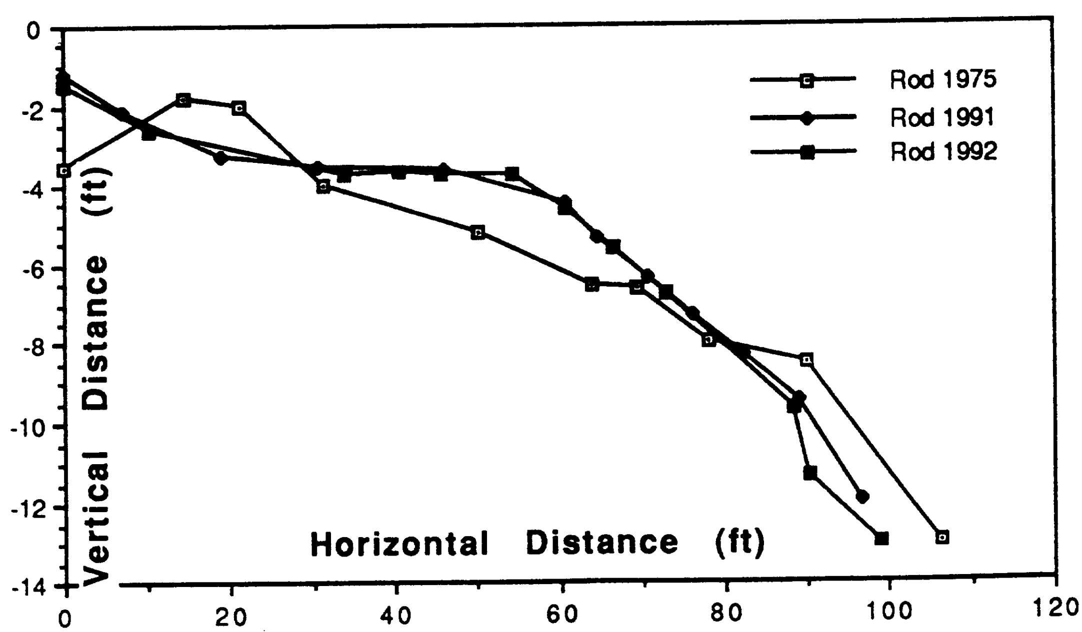


Figure 6. R 61.8 CS1

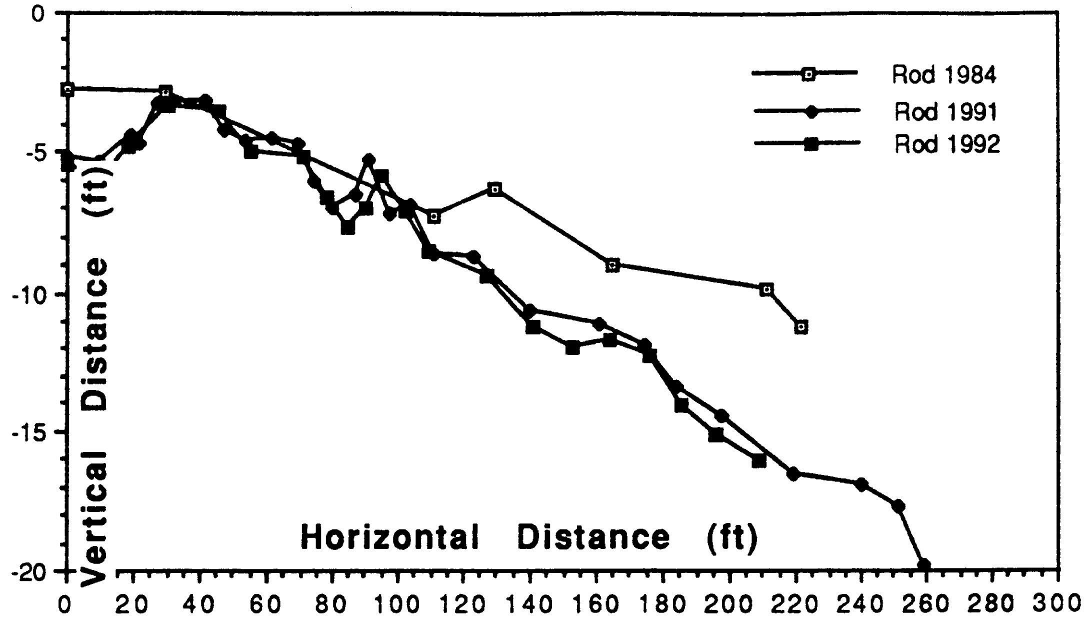


Figure 7. L 75 CS1 Nevills Rapid

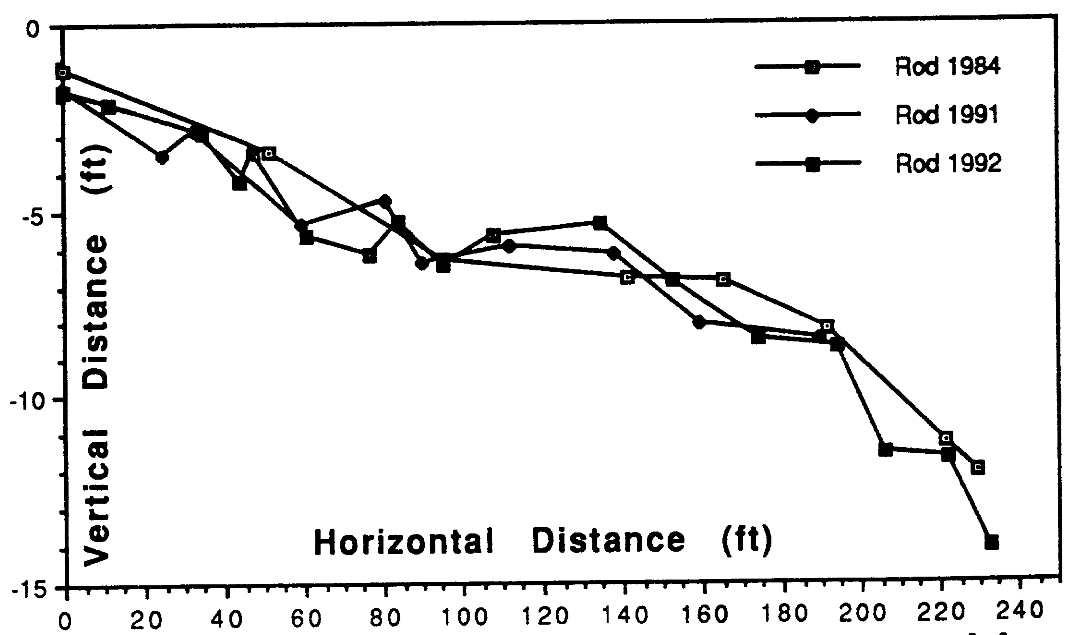


Figure 8. L 75 CS2 Nevills Rapid

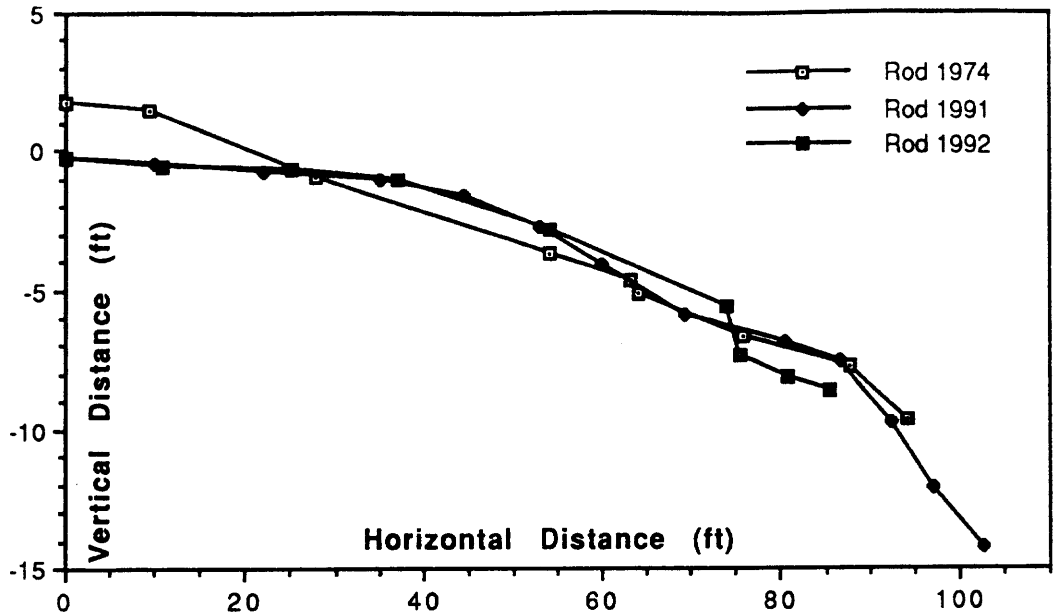


Figure 9. L 81.1 CS1 Grapevine

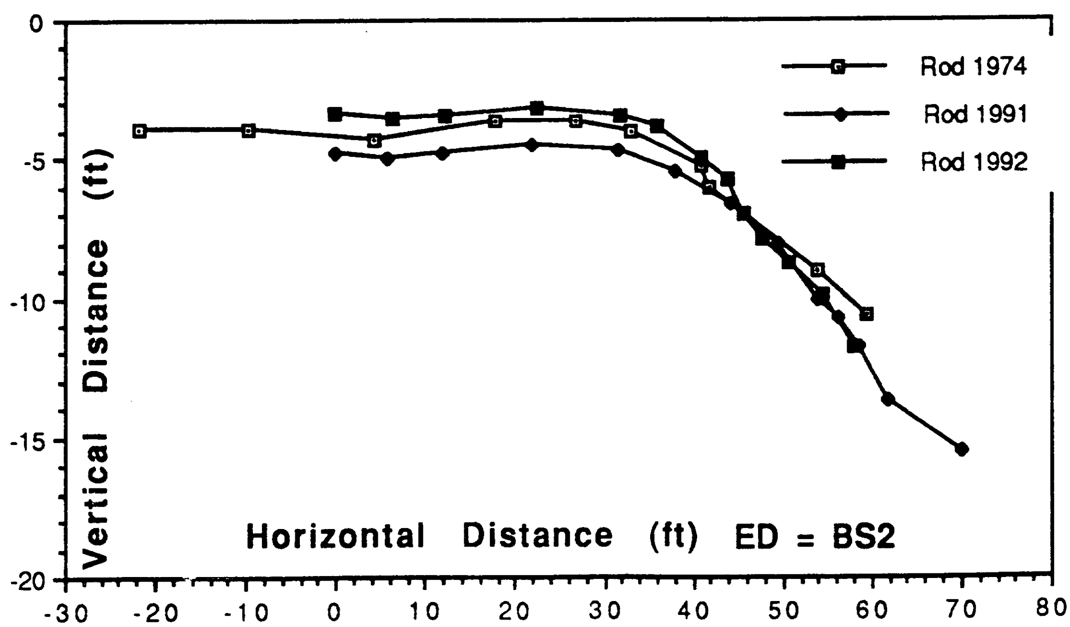


Figure 10. L 81.1 CS2 Grapevine

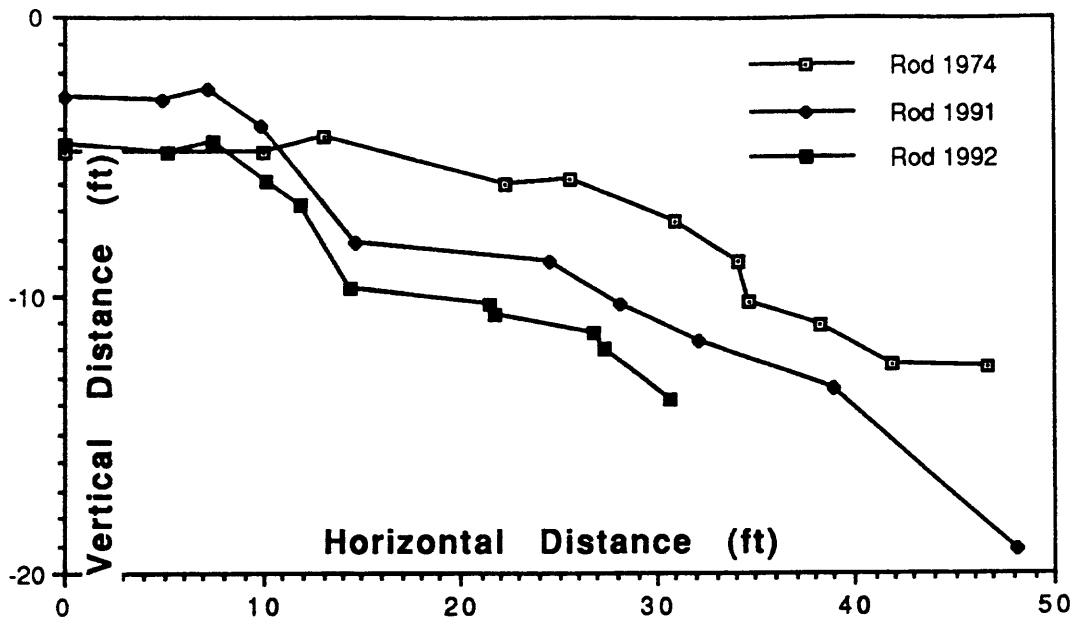


Figure 11. L93.2 CS1 Granite Rapid

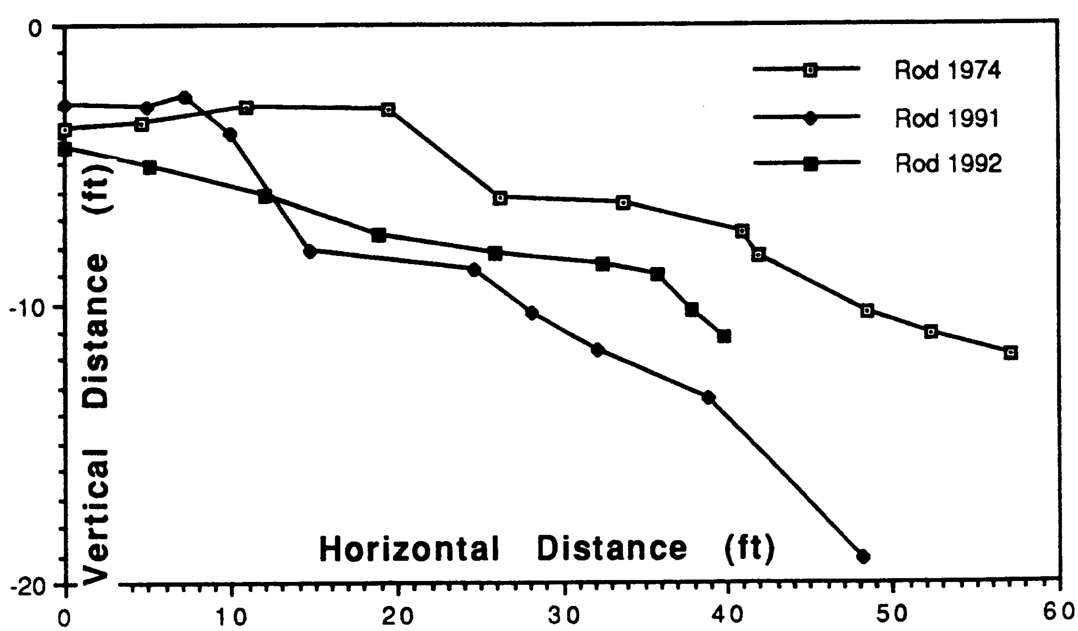


Figure 12. L 93.2 CS2 Granite Beach

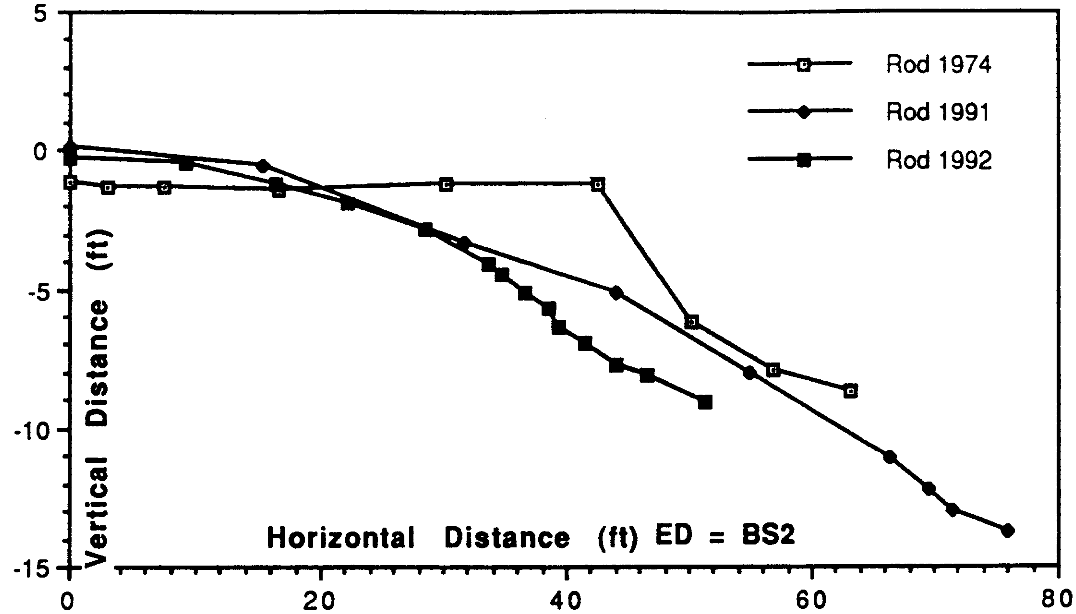


Figure 13. R 120.1 CS1 Blacktail Can

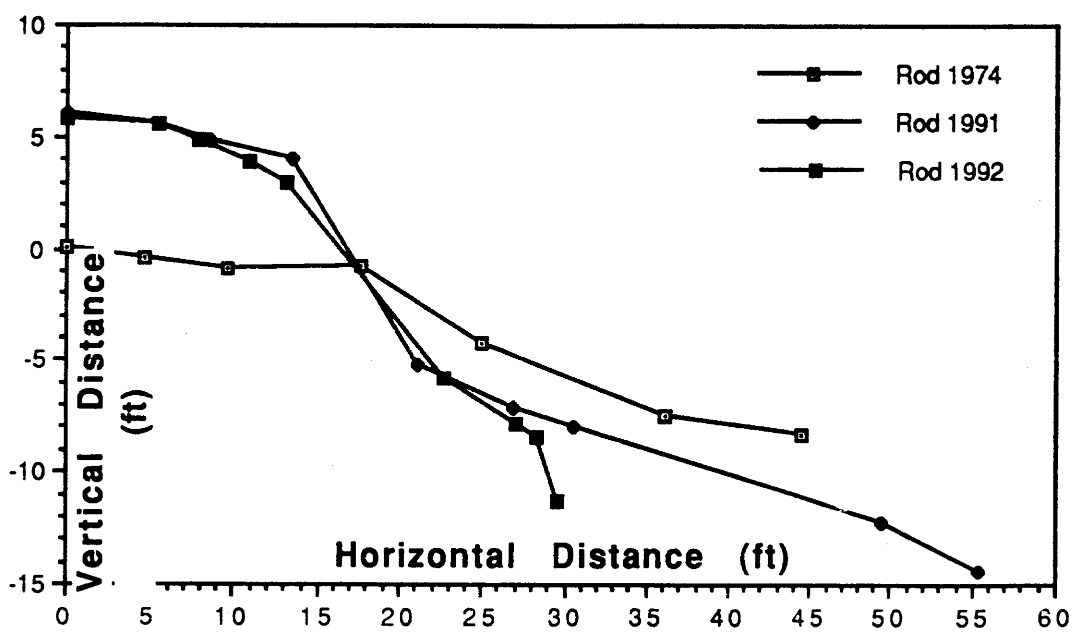


Figure 14. R 120.1 CS2 Blacktail

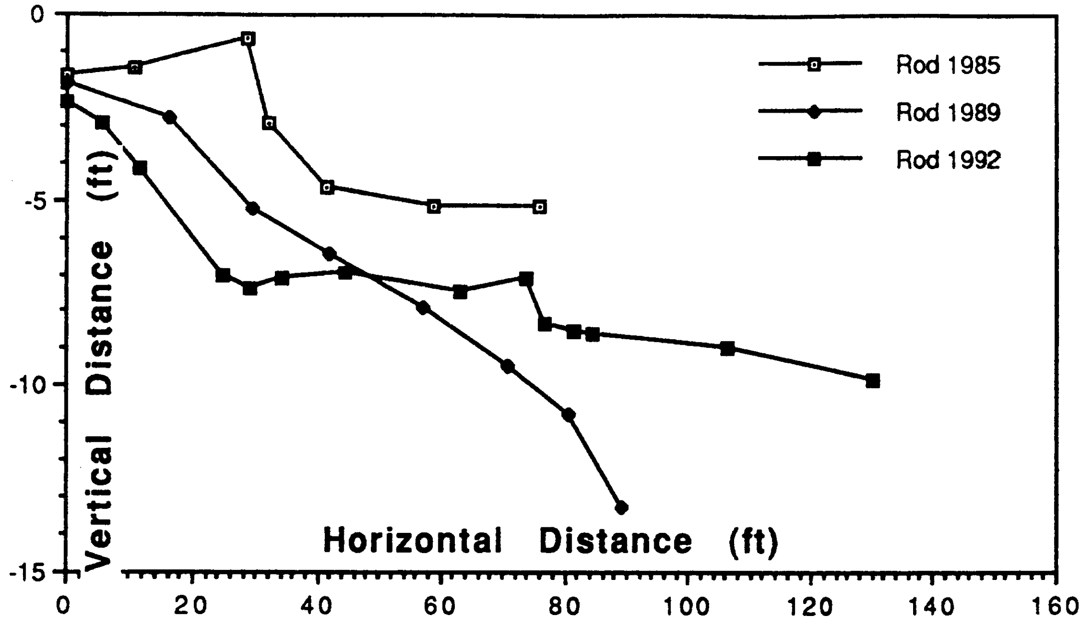
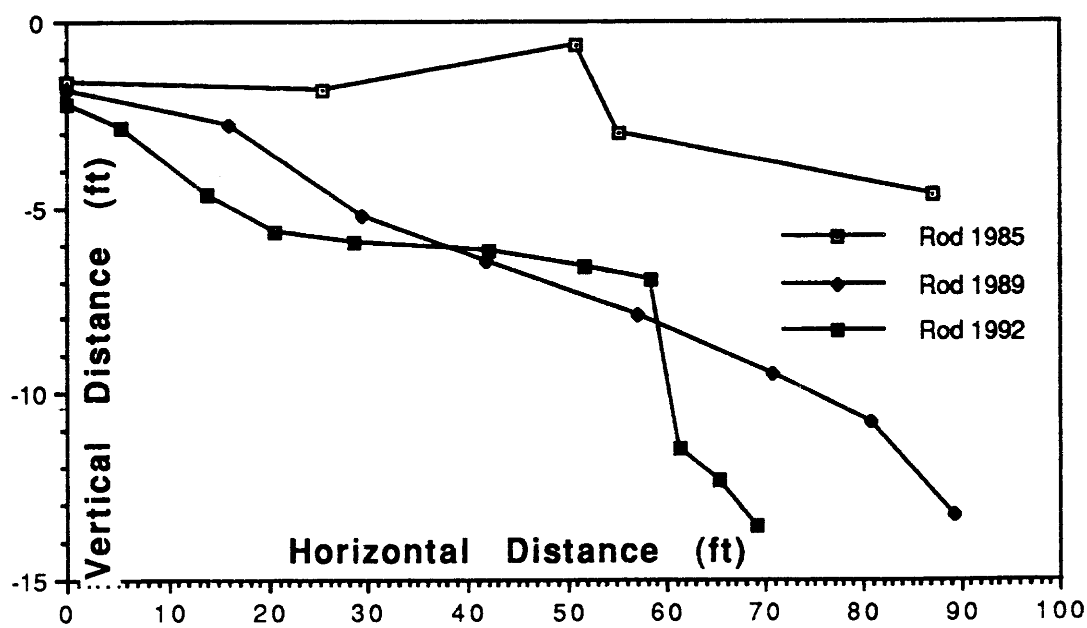


Figure 15. R 122.0 CS1



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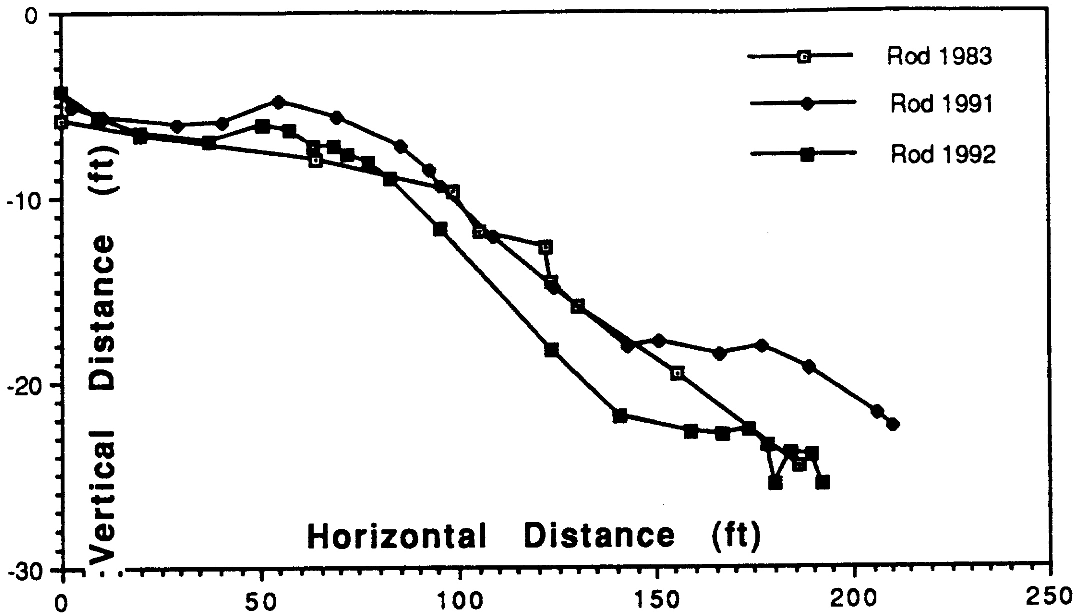


Figure 17. L 122.8 CS1 Forester Can

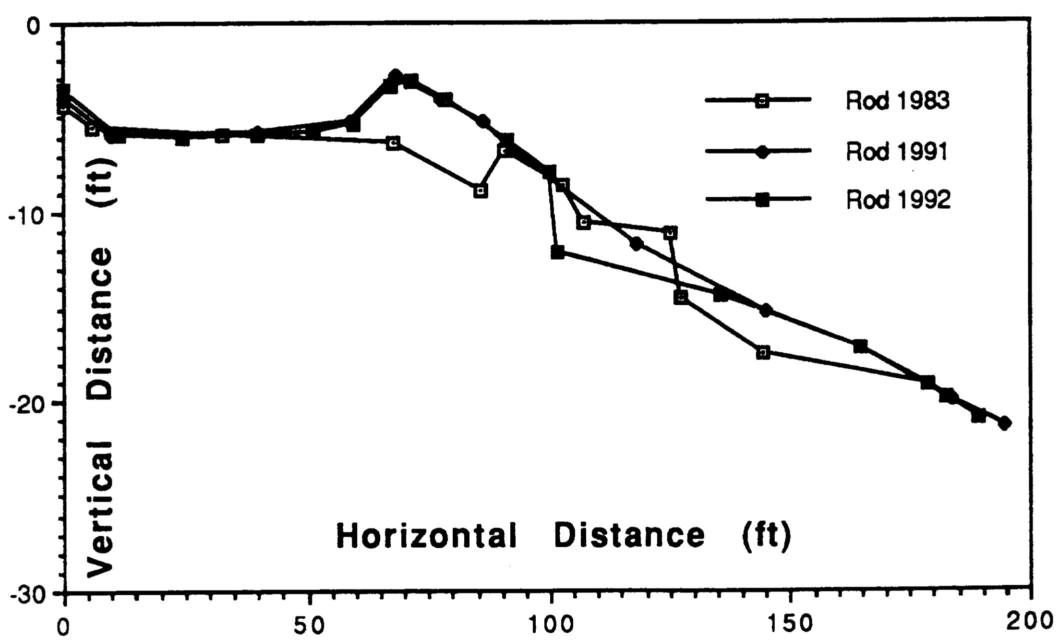


Figure 18. L 122.8 CS2 Forester Can

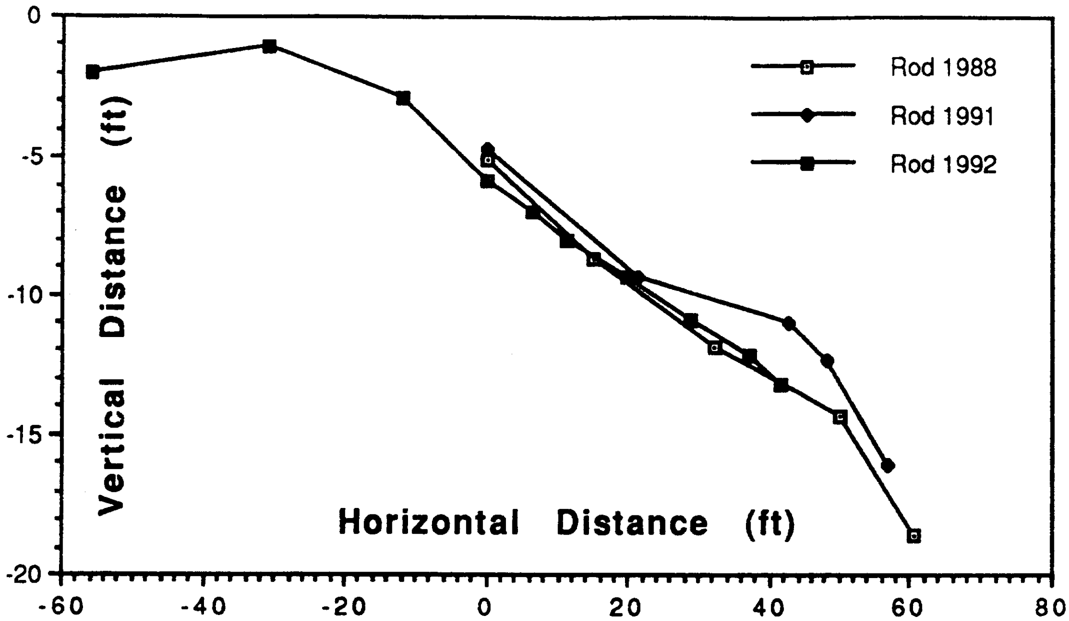


Figure 19. L 136.6 CS1 Poncho's Kitchen

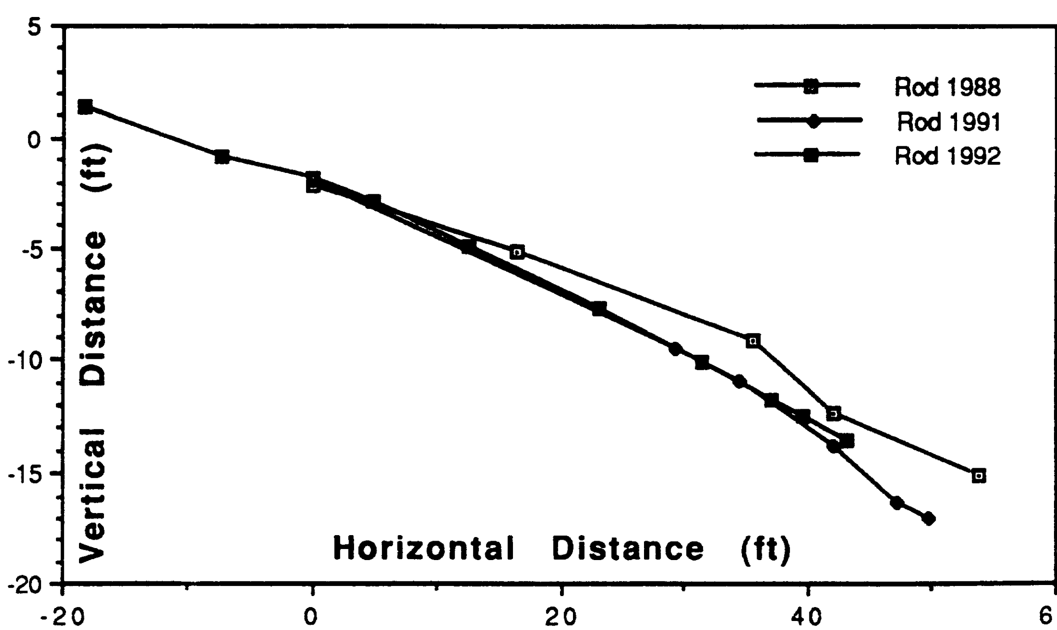


Figure 20. L 136.6 CS2 Poncho's Kitchen

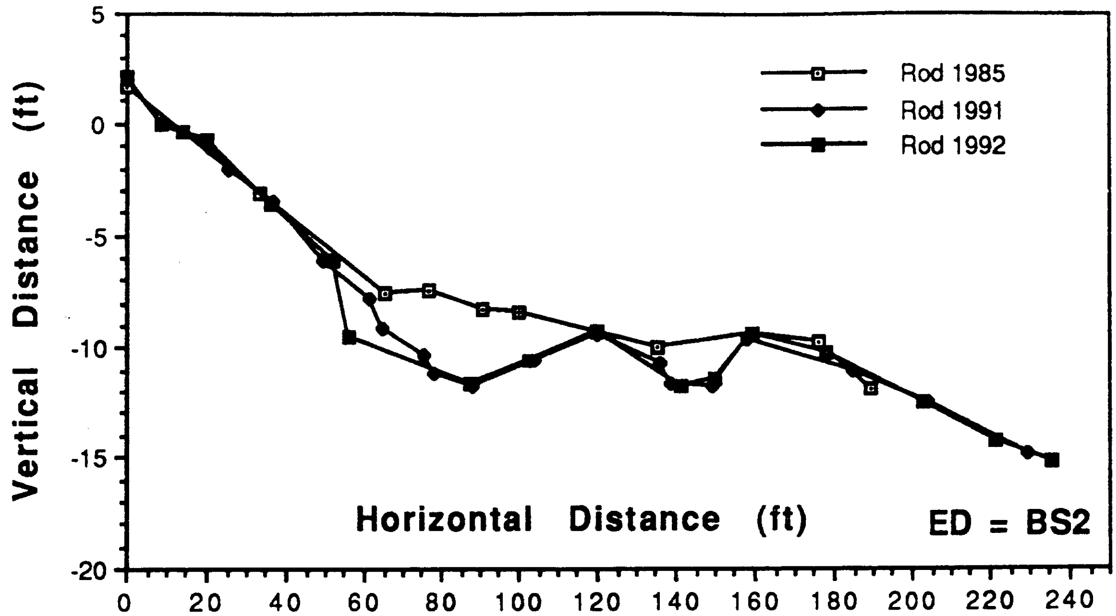


Figure 21. L 166.6 CS1 Lower National

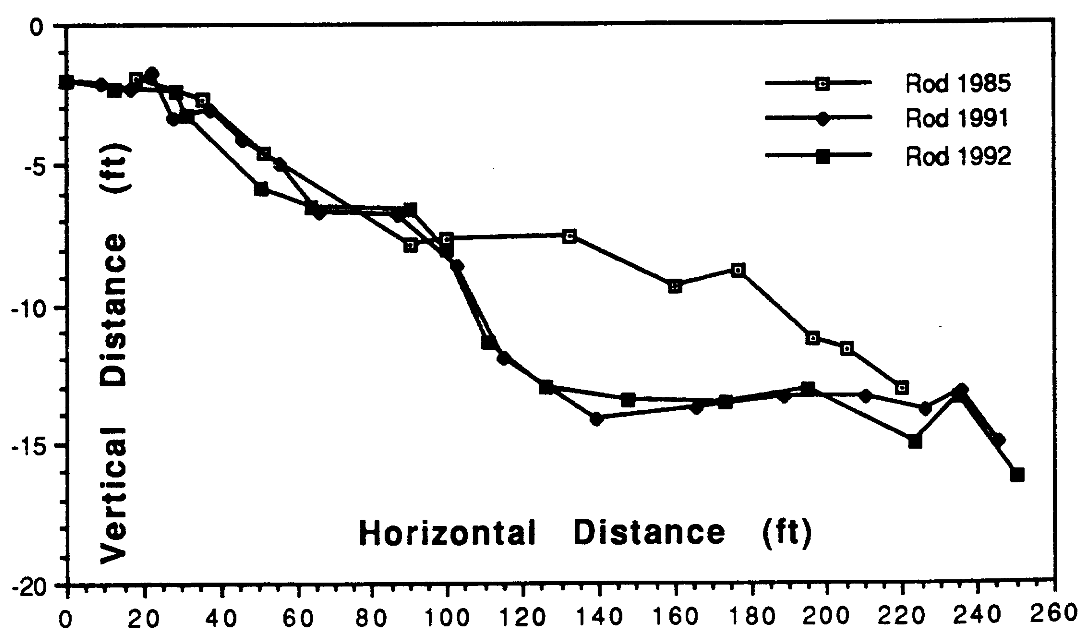


Figure 22. L 166.6 CS2 Lower National

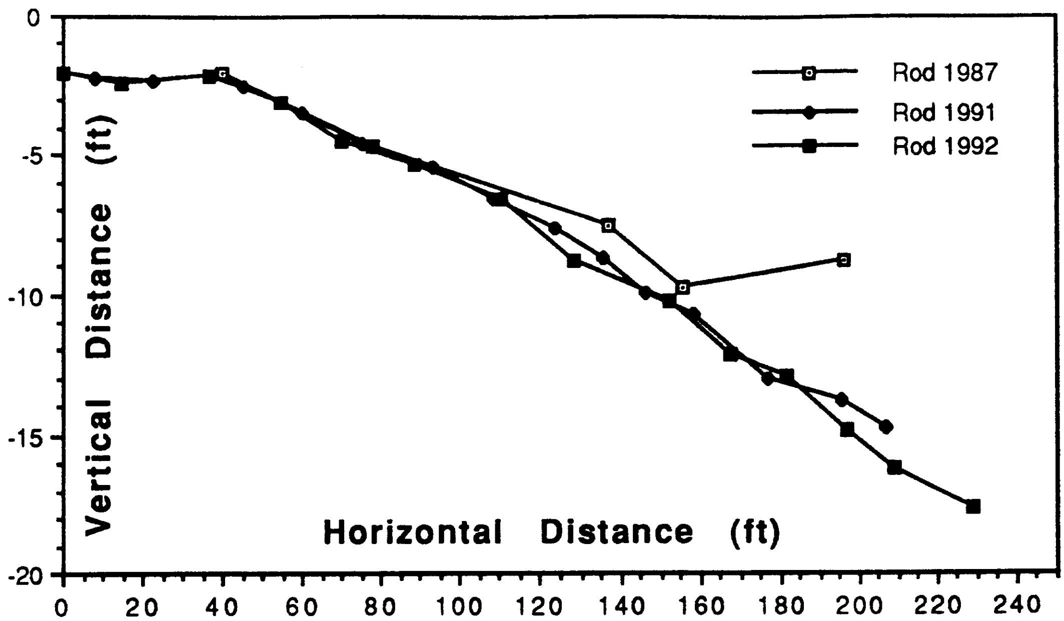
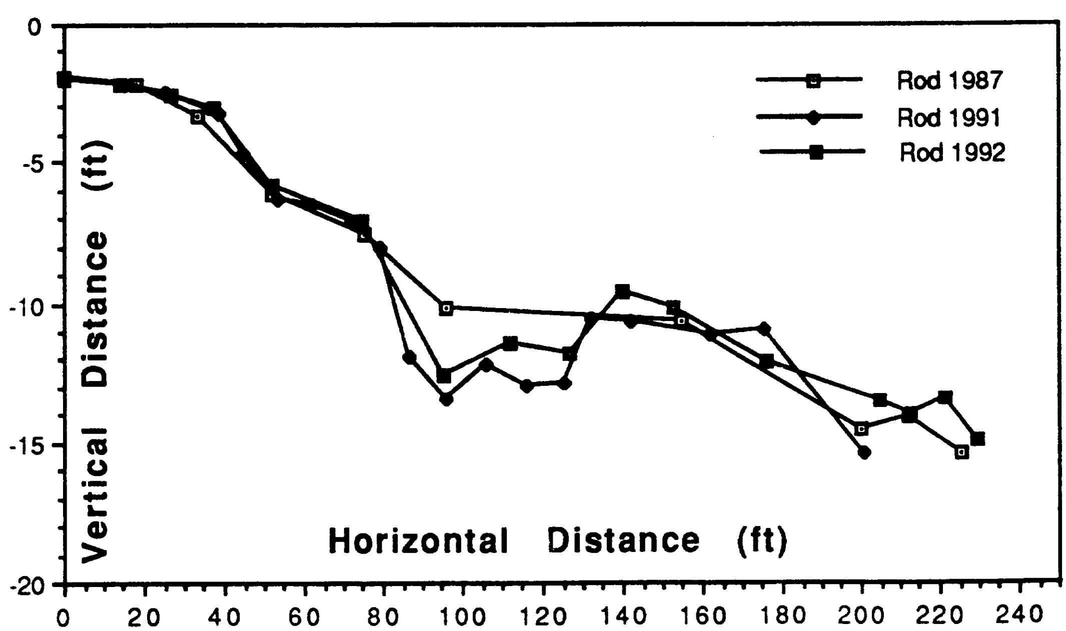


Figure 23. L 166.6 CS3 Lower National



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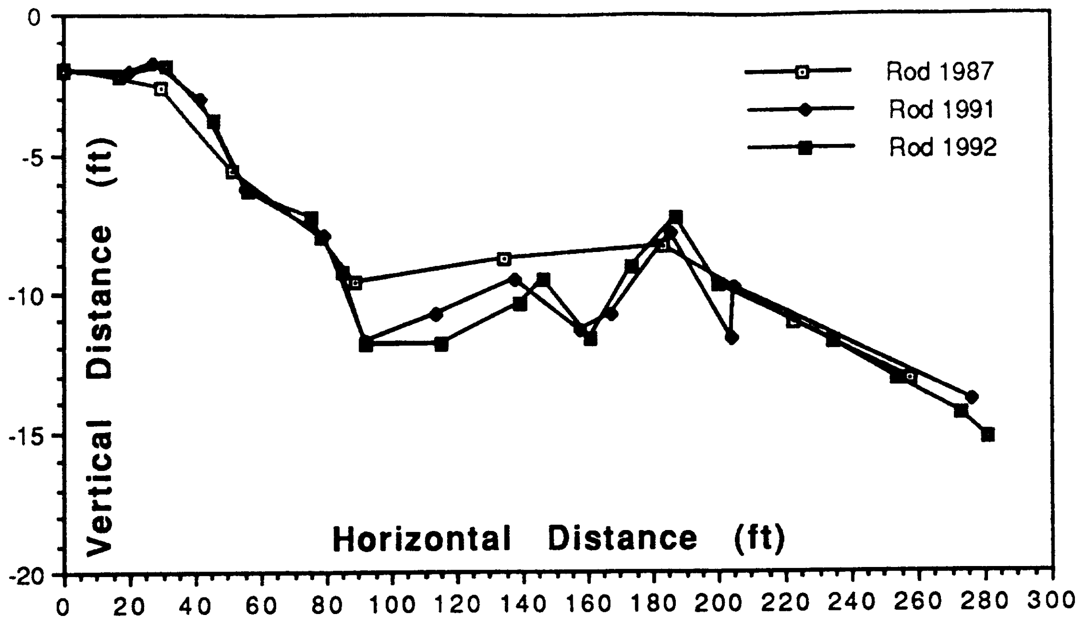


Figure 25. L 166.6 CS5 Lower National

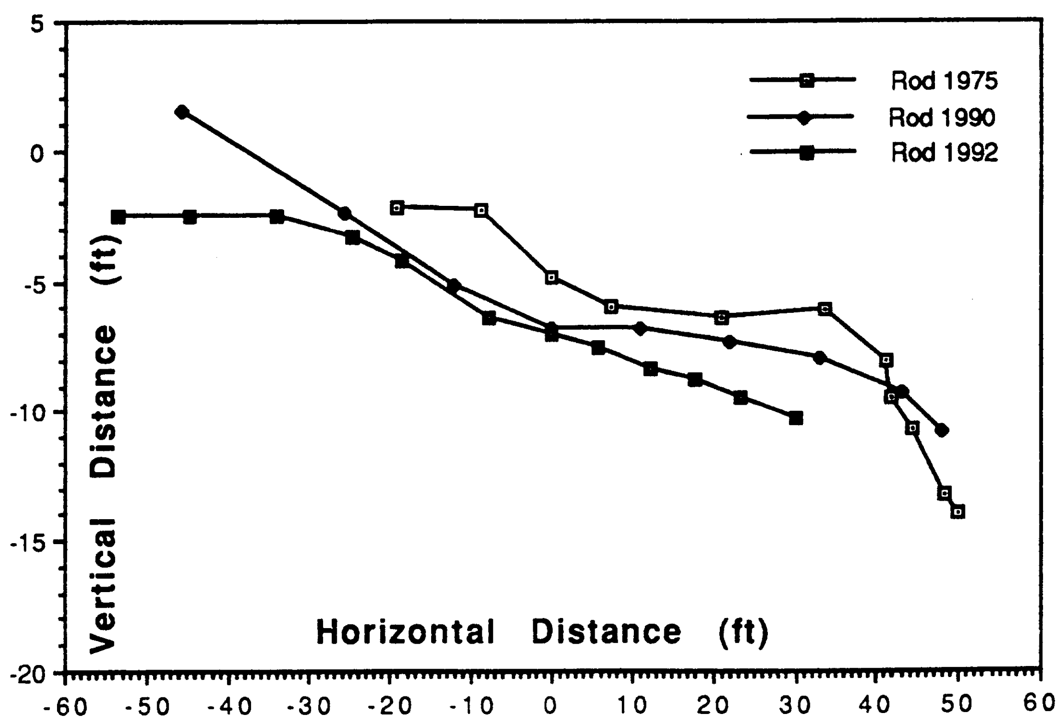
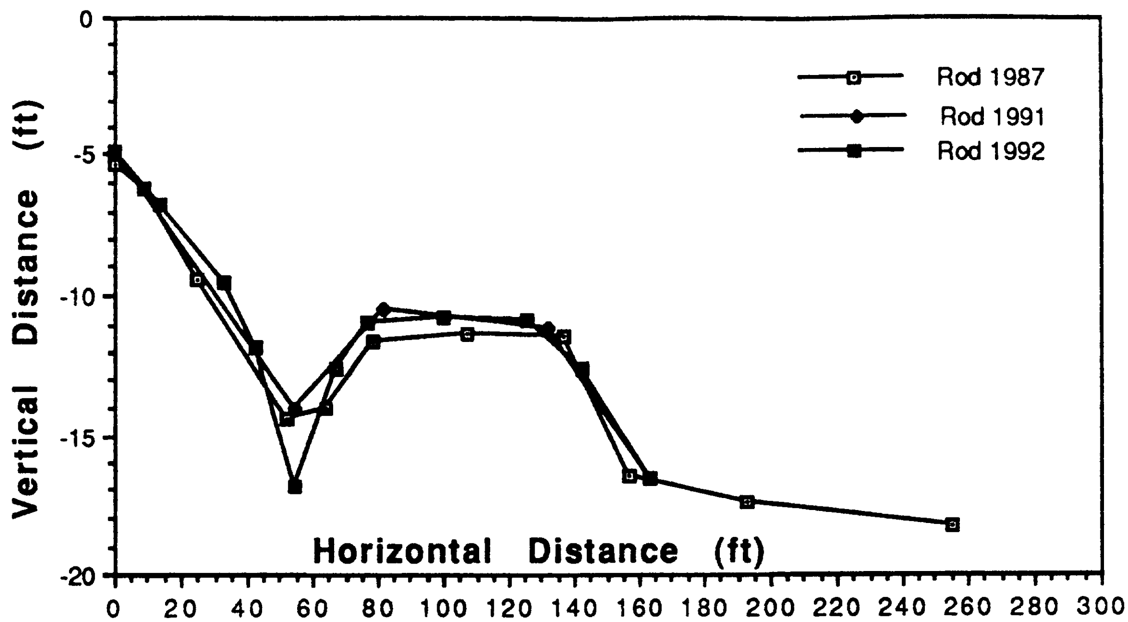


Figure 26. L190.2 CS1



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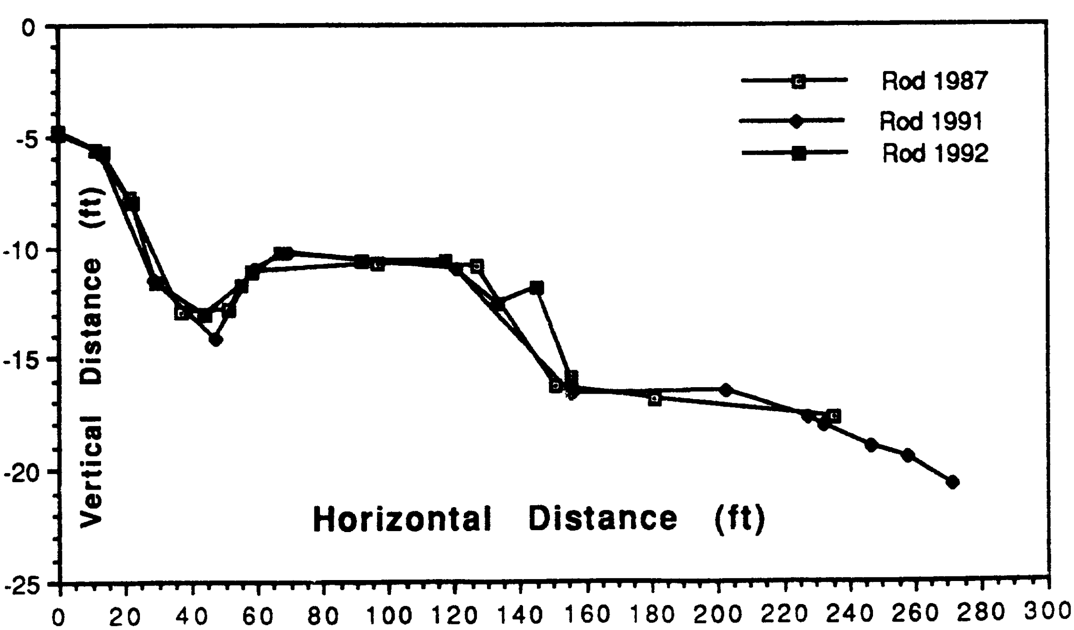
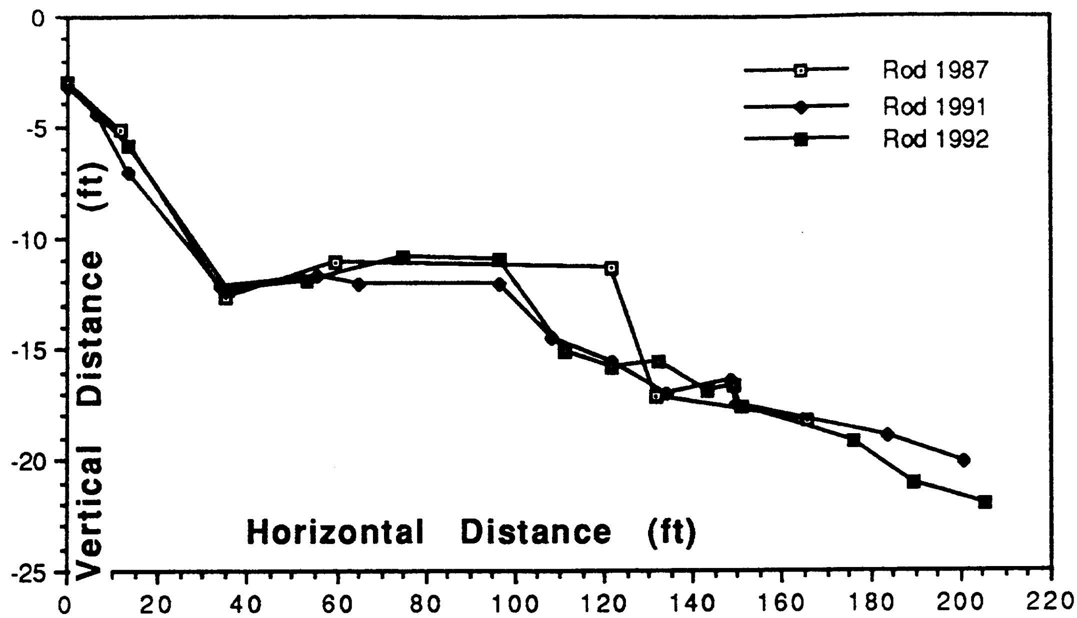


Figure 28. L 193.9 CS2



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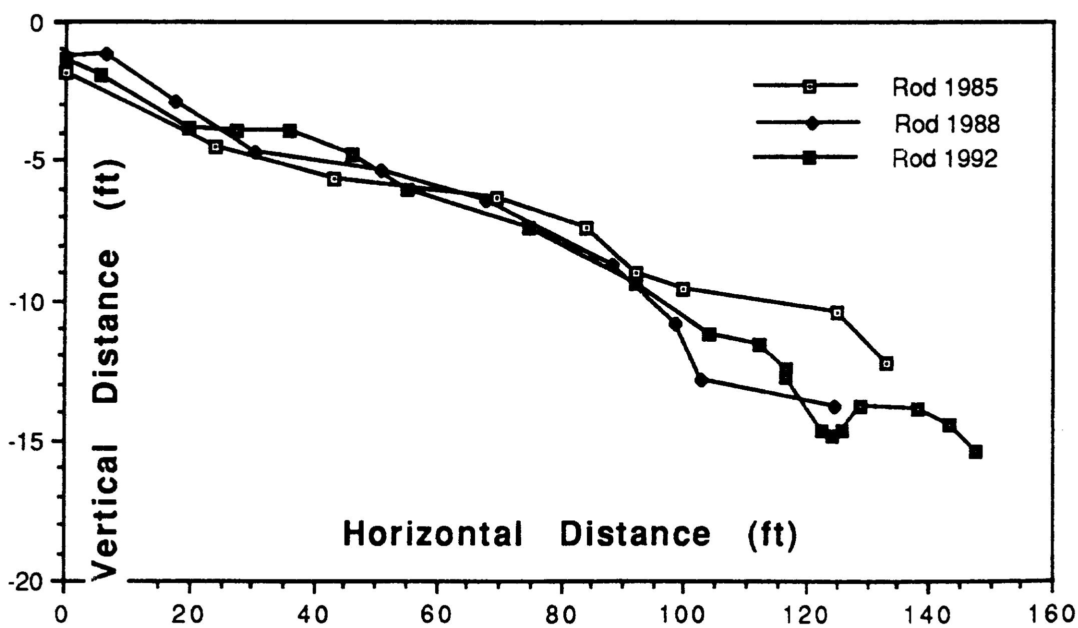

Figure 30. R 220 CS1

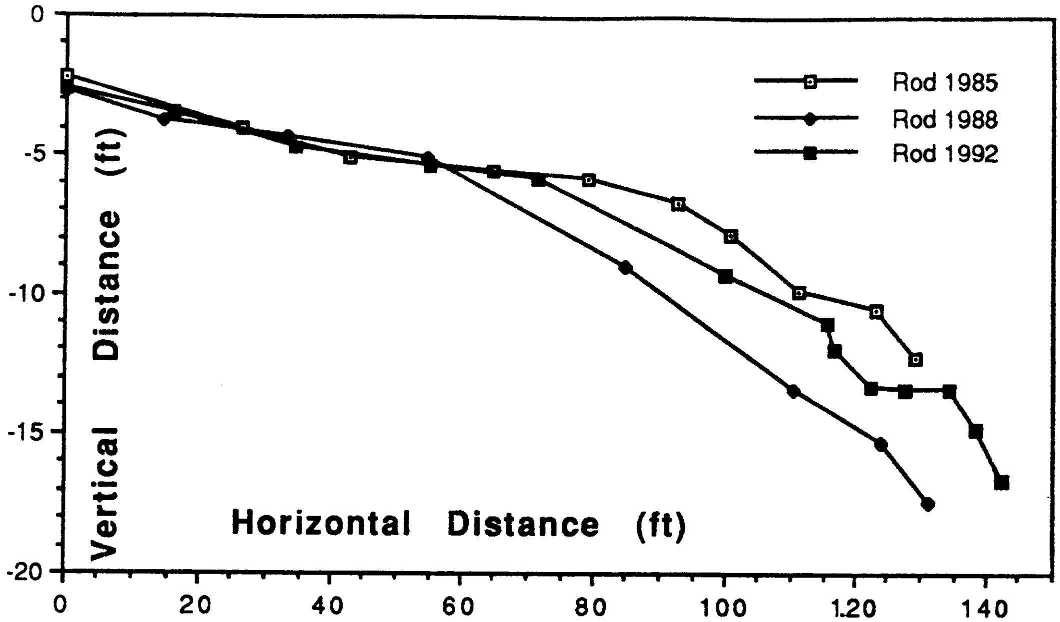

Figure 31. R 220 CS2

Table 2-2. Summary of Loss or Gain of Beach Sand

Beach	Profile	Comparison of 1991 and 1992 beaches Inner	Outer	Comparison of original beach survey to 1992 Inner	Outer	Original Study
L19.8	CS2	0.25	0.00	0.25	2.75	1989*
R31.6	CS1	-0.50	-0.25	-0.50	-0.25	1991
R31.6	CS2	-0.25	0.00	-0.25	0.00	1991
L34.7	CS2	0.00	0.00	4.00	-4.00	1974
R58.1	CS1	0.50	0.25	-1.75	-1.75	1984
R61.8	CS1	0.00	0.00	2.50	0.00	1975
L75.0	CS1	2.00	2.00	1.75	-2.50	1984
L75.0	CS2	0.00	0.25	-1.00	-0.50	1984
L81.1	CS1	0.00	0.00	-1.75	0.25	1974
L81.1	CS2	1.25	0.50	0.50	0.00	1974
L93.2	CS1	-1.00	-2.00	-3.75	-5.00	1974
L93.2	CS2	-1.50	2.75	-3.00	-3.25	1974
R120.1	CS1	0.00	-1.00	0.00	-3.00	1974
R120.1	CS2	-0.50	-0.50	3.50	-3.00	1974
R122.0	CS1	-1.75	2.25	-4.25	-2.75	1985*
R122.0	CS2	-1.00	-2.50	-3.00	-6.00	1985*
L122.8	CS1	-1.50	-2.75	0.50	-2.00	1983
L122.8	CS2	0.00	0.00	1.00	1.00	1983
L136.6	CS1	-0.75	-1.75	0.00	0.00	1983
L136.6	CS2	0.00	0.00	-0.25	-1.00	1988
L166.6	CS1	0.00	0.00	-1.00	-1.00	1987
L166.6	CS2	0.00	0.00	-2.50	-3.00	1987
L166.6	CS3	0.00	0.00	0.00	-2.00	1987
L166.6	CS4	0.25	0.25	-0.50	0.00	1987
L166.6	CS5	-0.25	0.25	-1.25	-0.75	1987
L190.2	CS1	-2.00	-1.75	-2.50	-3.00	1975
L193.9	CS1	0.00	0.00	0.50	0.00	1987
L193.9	CS2	0.00	0.25	0.00	0.25	1987
L193.9	CS3	0.25	0.00	0.00	-1.00	1987
R220	CS1	0.00	0.75	0.50	-1.50	1985*
R220	CS2	0.00	2.25	0.00	-1.75	1985*

* L19.8 CS2: Comparsion of 1990 to 1992 beach surveys.
* R122.0 CS1-2: Comparsion of 1989 to 1992 beach surveys.
* L190.2 CS1: Comparsion of 1990 to 1992 beach surveys.
* R220 CS1-2: Comparsion of 1988 to 1992 beach surveys.

NOTE: The designation of inner and outer beach is made by dividing the graph subjectively in half, the inner beach half being away from the water's edge and the outer beach being near the water's edge.

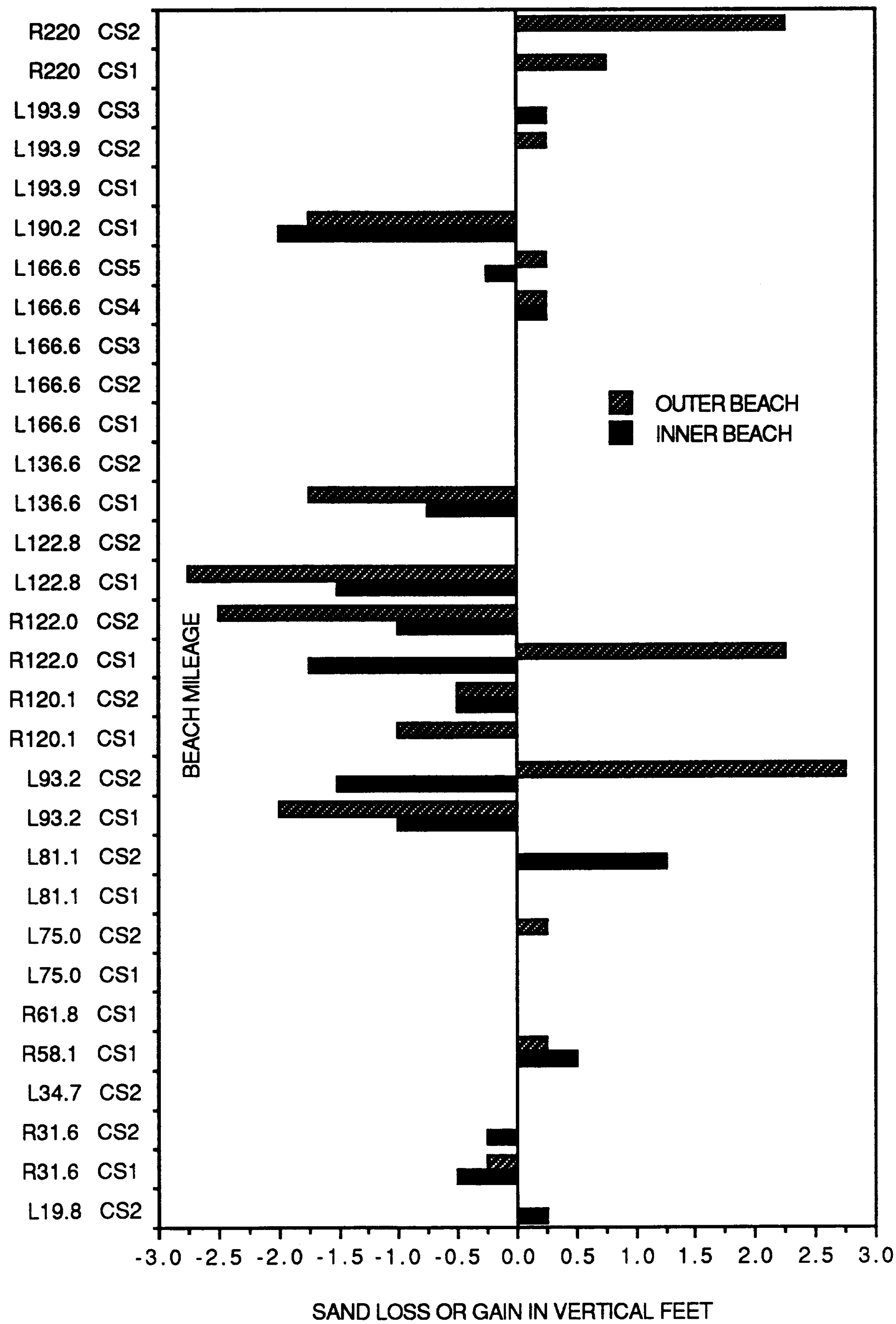

Figure 32. Gain or loss of sand from selected beaches, 1991-92.

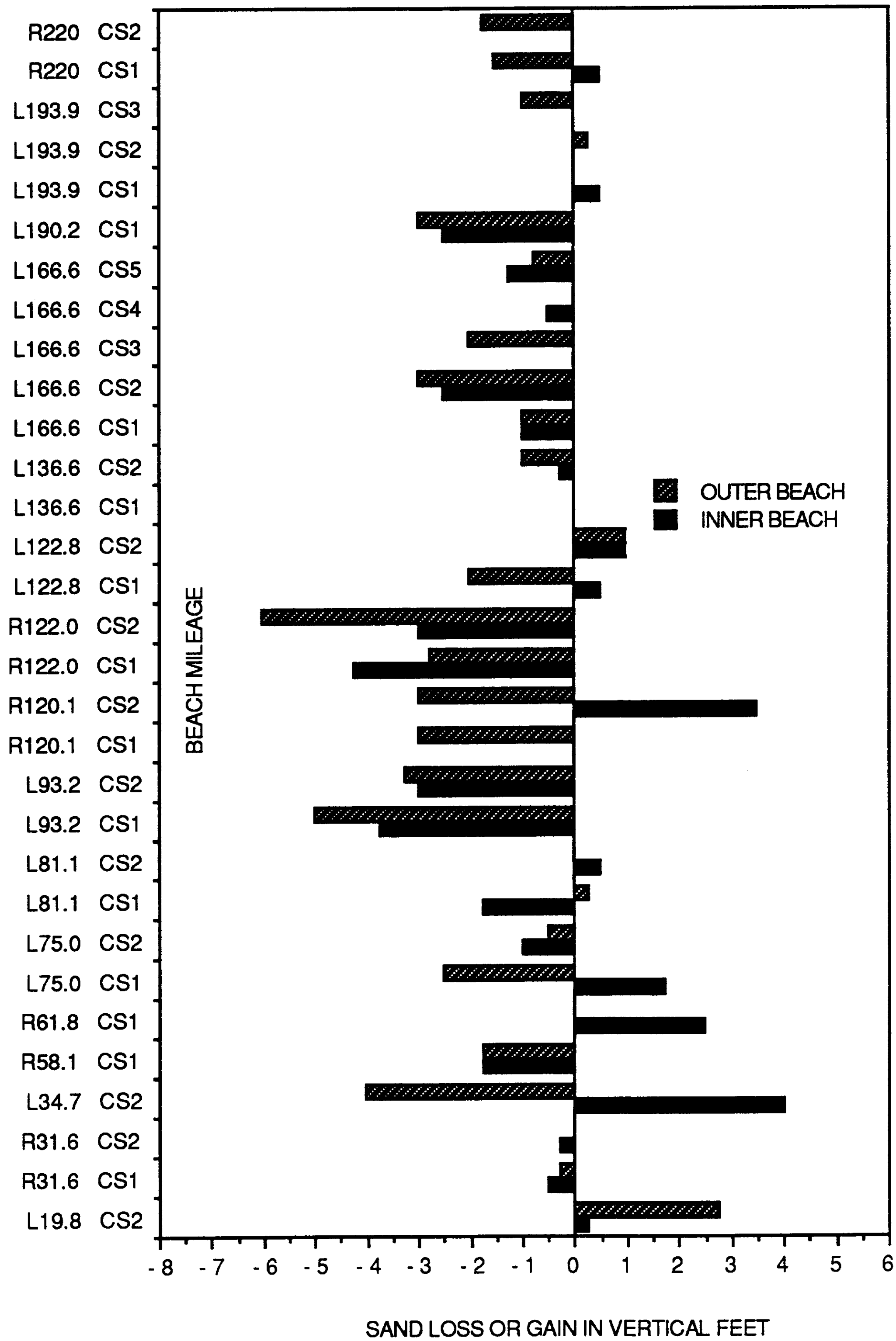

Figure 33. Gain or loss of sand from original survey to 1992

Results

Summary of Results:

Comparison of inner beach profiles since last recorded survey:

- 36% lost sediment
- 45% remained the same
- 19% gained sediment

Comparison of outer beach profiles since last recorded survey:

- 26% lost sediment
- 39% remained the same
- 35% gained sediment

Comparison with original survey-inner beaches:

- 48% lost sediment
- 20% remained the same
- 32% gained sediment

Comparison with original survey outer beaches:

- 68% lost sediment
- 16% remained the same
- 16% gained sediment

Conclusions

In comparing data from our 1992 survey to the last recorded survey in 1991 we found, out of 31 cross sections,11 of the inner beach sites experienced a loss of sediment, 6 showed a gain and 14 sites remained unchanged. Outer beach comparisons resulted in 8 cross sections showing a loss,11 gaining and 12 showing no change in their amount of sediment.

In the previous 12 months it appears the predominant trend has been one of little change. On balance, there was more loss than gain on the beaches studied.

When correlating our 1992 data to the original survey data we determined that 14 of the inner beach profiles lost sediment,10 gained and 6 remained unchanged. The outer beach profiles showed 20 beaches lost, 4 gained and 6 remained unchanged.

In comparison to the original survey, the profiles continue to show a loss of sediment, especially on the outer beach areas. Most gains and losses of inner beach sediments are probably due to shifting wind-blown sand from other areas of the beach. The gains along the outer beaches may be due to the deposition from side canyon flooding, along with redistribution of sediments from other parts of the beach.

Beach comparisons with previous surveys were difficult at times due to problems with vegetative growth, altered beach topography and changed or lost base stations. In succeeding years, extending cross sections into the water as far as possible will compensate for high or low levels and coordinate profiles more adequately.

Chris Brod, a professional surveyor, double-checked our survey readings at CS1, 2, 3, 4 and 5 at Lower National Canyon. Our conventional survey methods, using a transit, were found to be accurate to one tenth (.1) of a foot with measurements obtained with the laser transit (Lietz SET and SET 4C electronic total station).

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ADDENDUM 1-1

To Beach Profile Survey Team:

1. To increase speed and accuracy of data collection, we recommend training and sticking to specific job assignments while in the field. Rotating tasks in order to learn various roles and discover the most efficient and functional assignments for each team can be accomplished during instructional field trips prior to the river trip.
2. To simplify your data summary and final report, we suggest the following be done as you collect your data or on layover days during the raft trip:
a. identify which BS is to be used for zero point on graphs and record it as ED (Elevation data) on the bottom of each data sheet;
b. correct for barrel tilt. Accuracy of the tilt angle is most important, especially over long distances when the length of line may not be quite true (due tointerference of rocks and trees, extreme sloping of beaches, sagging of the measuring tape).
3. Rod Person:
a. watch transit person for directions at all times during readings;
b. pick or plant two points (a stick, someone's shoes) to help you keep in line with the transit as you back up holding the rod;
c. keep your hands alongside the rod so as not to block the numbers.
4. Line People:
a. try for a true horizontal between you to eliminate slope effect on measurement;
b. do not exceed limit of line strength as lines do break.
5. Transit Person:
a. shoot both base stations on each cross-section;
b. if barrel is tilted for BS, try for 0.00 reading;
c. if barrel is tilted otherwise, try for whole degree reading.
6. Recorder:
a. prepare data sheets in advance by entering "mile, date, cross-section number,campground name" at top;
b. have old report and old data sheet for each beach;
c. have maps at hand; get BS to CS distances from the map while in the field;
d. under "Comments", give reasons for tilting the transit barrel, reasons for skipping a cross section, and locations for each rod reading.
7. General:
a. practice setting up and calibrating transit before leaving for the river. This is the most time consuming aspect of the beach profile;
b. keep hand lenses on hand as readings are hard to make off transit without them;
c. make every attempt to recover buried benchmarks as they will increase the accuracy of results;
d. upon return from the river assign one member of the team to become familiar with the graph generating software to be used (Cricket graph on a Macintosh computer). This will make producing research reports much easier;

e. wear bright hats in field to aid with visibility of each other. Neon orange is most easily seen;
f. be consistent in readings for BS; BSI upstream and following BS's downstream in numerical order;
g. have a consistent ED, BS1 used always, if possible;
h. keep all future research/data on one disk;
i. more adequate communication between the rodperson and the transit person would be possible with the use of a walkie talkie;
j. have available good measuring tapes, 200 feet measured in tenths;
k. Bubble level for the survey rod.

CHAPTER 2

BEACH SURVEY GROUP II

CHRIS BROD AND JIM MATHEWS

INTRODUCTION

Traditional transit survey teams from Northern Arizona University (N.A.U.) have been a part of the Grand Canyon Experience (GCE) workshop annually for the past ten years. The purpose of these activities was to survey beach sites. Information gained from these surveys help to determine the loss or gain of sand from the beach environment in the river corridor. The integrity of the beaches has profound impacts on recreation in the canyon and also impacts flora and fauna in the riparian zone. Concerns over peoples' impact on the river corridor are so great that an environmental impact study was mandated in 1989. The information obtained by the survey team has become an important component of the environmental impact studies. Recently, the Glen Canyon Environmental Studies Group (GCES) has been conducting surveys of their own. They sent Chris Brod, a professional surveyor, to work with the Beach Survey Team. This surveyor was to locate the benchmarks previously used by the GCE survey team, catalogue these points, and cross reference them with benchmarks used by the GCES group. The GCE survey lines will then be networked into the Geographical Information System (GIS), a complicated system that integrates all of the information collected along the river corridor.

As a result of the work completed by Chris Brod and myself, not only is the information gathered by Dr. Beus part of the COLORADO RIVER INVESTIGATIONS record, but our cross-referencing has made it easier to retrace the previous profiles using different locations and benchmarks. This replication could prove critical to other scientists and to the understanding of beach dynamics in the Grand Canyon.

PROCEDURE

The old benchmark and backsight used by GCES would be located at each beach. An infra-red survey instrument would be placed on that benchmark and a reflector would be set up on the GCES backsight. These benchmarks and backsights were also located with distance and angle recorded. A few beaches did not have GCES benchmarks; when this happened, a new point would be established and catalogued to correlate with the previous points. Some GCES benchmarks were inaccessible due to high water, rock slides or being on the opposite side of the river. In these cases, the GCES benchmark would be documented by photographs. These sites will be surveyed and catalogued at a later date.

RESULTS

Mixed results were obtained from the cross checking of beach profiles. In general, the two groups matched. The starting and stopping point on the beach frequently correlated. However, even though the overall trend is consistent, errors and discrepancies are apparent. There are two major blunders that are evident from Cross Section 1 (Chart 1) and Cross Section 4 (Chart 4). Cross Section 1 (CS1) has a consistent one foot elevation difference between the two surveys. Possible explanations for this can be:

A) error in mathematical calculations;

B) confusion due to changing the backsight. CS1 was the only cross section that used a different backsight. It is possible that in previous studies the other backsight was used;

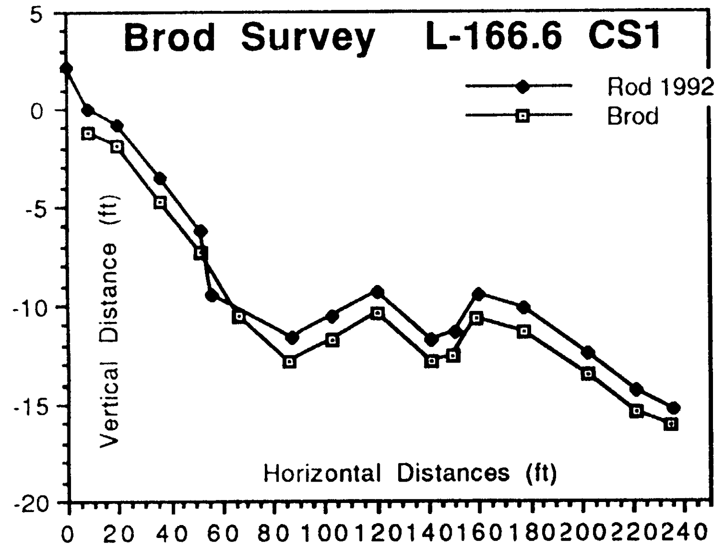
C) in reading the instrument height(HI), the elevation calculations might have been off by one foot.

The two surveys mirror each other with one minor exception (Chart 1), which looks like a ten foot error in reading the tape (tape bust).

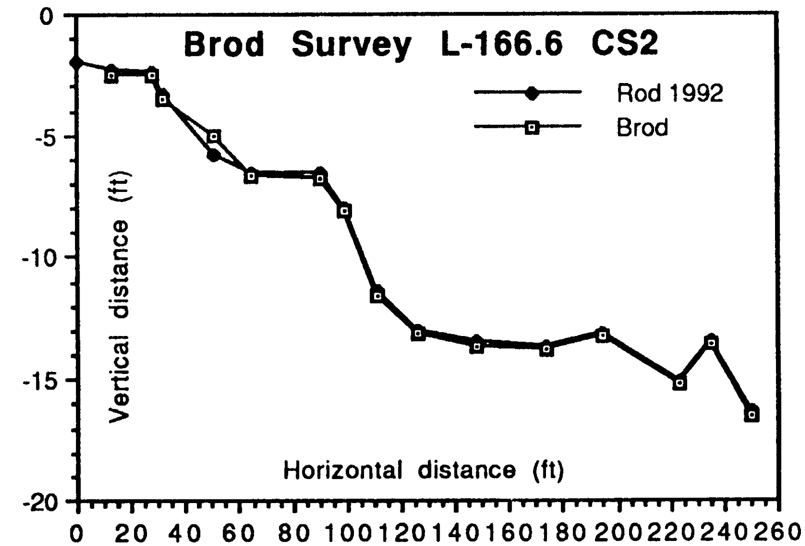
Cross Section 4 was the other major blunder (Chart 4). There is a steadily increasing distance between the two lines in the graph. This may be explained by:

A) the instrument tripod may have been sinking into the sand;

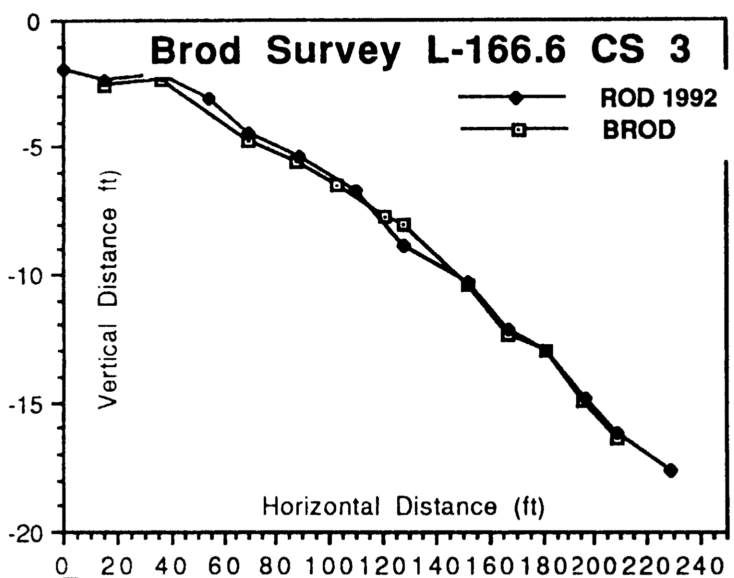
B) the barrel may have been not quite level, therefore it may have been gently tilting up through the readings and moving it off level.


Brod Survey L-166.6 CS1
Rod 1992
Brod
Vertical Distance (ft)
Horizontal Distances (ft)
5
0
-5
-10
-15
-20
0 20 40 60 80 100 120 140 160 180 200 220 240

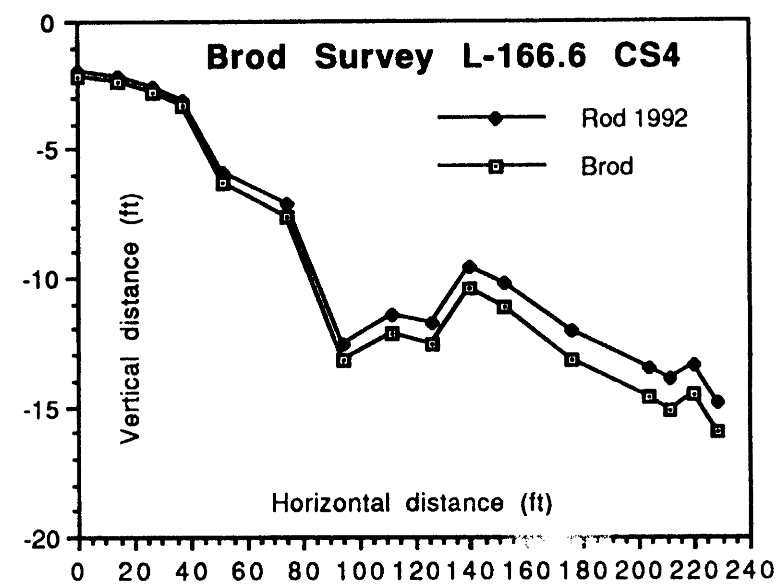
1


Brod Survey L-166.6 CS2
Rod 1992
Brod
Vertical distance (ft)
Horizontal distance (ft)
0
-5
-10
-15
-20
0 20 40 60 80 100 120 140 160 180 200 220 240 260

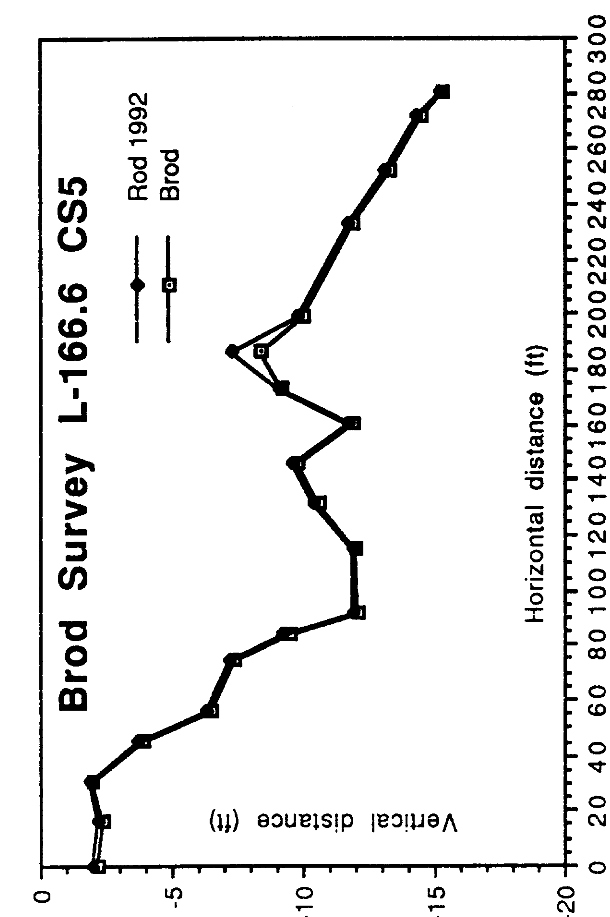
2


Brod Survey L-166.6 CS 3
ROD 1992
BROD
Vertical Distance ft)
Horizontal Distance (ft)
0
-5
-10
-15
-20
0 20 40 60 80 100 120 140 160 180 200 220 240

3


Brod Survey L-166.6 CS4
Rod 1992
Brod
Vertical distance (ft)
Horizontal distance (ft)
0
-5
-10
-15
-20
0 20 40 60 80 100 120 140 160 180 200 220 240

4


Brod Survey L-166.6 CS5
Rod 1992
Brod
Vertical distance (ft)
Horizontal distance (ft)
0
-5
-10
-15
-20
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300

5

The second explanation appears to be the most logical. If the graph is in error, it would be expected that this cross section would show increasing discrepancy with the sediment. This did occur. There is a strong possibility that the data is unreliable.

The remaining three cross sections have only minor problems. Cross Section 2 seems to be identical between the two surveys (Chart 2) with one tape bust (a missed horizontal distance of ten feet and one rod bust (a missed elevation of one foot), This should not significantly affect the outcome of the profile. The most problems of these three cross sections occurred with CS 3. This cross section was the first profile started, therefore it was subject to human error. The six member beach profile team started prior to the GCES team. This resulted in the GCES team missing at least one point and placing an extra point in the profile. This did not appear to significantly affect the cross section profile. The last profile, CS 5, was very accurate with the exception of one ten foot tape bust and one rod bust of one foot (Chart 5).

CONCLUSION

For the most part the two surveys coincided. However, the accuracy of the surveying can be improved upon. The following chart is a summary of the results:

PERCENTAGE OF ERRORS FOR EACH CROSS SECTION (L 166.6)

L 166.6 CROSS SECTIONS	NAU ROD BUST (1 FT)		NAU TAPE BUST(10 FT)		GCEIS TEAM	
CS 1	0.00%	0/15	6.66%	1/15	0.00%	0/15
CS 2	6.66%	1/15	6.66%	1/15	0.00%	0/15
CS 3	0.00%	0/13	0.00%	0/13	**16.66%	2/12
CS 4	* N/A		*N/A		0.00%	0/16
CS 5	5.55%	1/18	5.55%	1/18	0.00%	0/18
TOTAL	TOTAL		TOTAL		TOTAL	
	3.28%	2/61	4.92%	3/16	2.63%	2/76

* CS 4 Data was so divergent as to be noncorrelating

** The GCEIS team misplaced one point and added another point which did not belong in the data

RECOMMENDATIONS

To enhance this study I suggest the following:

1) Hand held radios to help eliminate miscommunication;
2) Standardized duties - have each person keep the same job in order that they will become proficient in their duties;
3) Study conducted under more favorable seasonal conditions. Some beaches were so hot (sand temperature of 150 F.) that the surveyors may have rushed their jobs.

CHAPTER 3

HUMAN IMPACT STUDY ON THE BEACHES OF THE COLORADO RIVER IN THE GRAND CANYON

NEAL AYRES, LAURA CRAFT, JOHN DOLE, TAMSEY ELLIS, JENNY McCUTCHEON, TANYA SPURGIESZ

Since the Human Impact section of the COLORADO RIVER INVESTIGATIONS is a continuing study which began in 1981, the majority of the following sections were copied verbatim from previous studies: "INTRODUCTION, OBJECTIVES, and METHODS". In an effort to bring about a better understanding of some procedures, and to include the new study on the organic percentage of matter found on the beaches, a few changes were made .

INTRODUCTION

Within the last twenty years two major and distinctly interrelated natural resource management problems have arisen along the river corridor of the Colorado River in Grand Canyon National Park.

1) The extensive environmental changes that have taken place in the hydrological characteristics of the river as a result of Glen Canyon Dam.
2) The dramatic increase in recreational use of the systems by river runners and hikers.

Although located fifteen miles upstream of the national park boundary, Glen Canyon Dam changed the nature of the Colorado River flowing through the Grand Canyon. Post-dam changes in water flow, water temperature, and sediment discharge have combined, often synergistically to alter the Grand Canyon river ecosystem. On one side of Glen Canyon Dam the wildly variable Colorado River has been buried beneath the deep waters of Lake Powell; on the other side, the river we still call the Colorado is now released through turbines and gates as a predictable, computer-regulated, icy cold, sediment-free, and partially tamed river. To further complicate the matter, the "new" dam-controlled Colorado River in the Grand Canyon has recently proven to be one of the most popular white-water recreation areas in the world, with a strict National Park Service permit system regulating and allocating both private and commercial use of the 225 miles of Colorado River from Lees Ferry to Diamond Creek. (GCNP 1981). The stabilized patterns of water flow established during the past twenty years have been disrupted only during the period from 1983-1985 when unusually high flows were released from Glen Canyon Dam and during 1992 when "interim flows" were imposed by court order during ongoing environmental impact studies.

Given the above considerations, the present challenges to developing an adequate system for resource management along the river corridor of Grand Canyon National Park include: a) determining the eventual ecological "steady-state" of the dam-altered river in terms of sediment erosion and deposition, vegetation and animal community composition, and overall ecosystem stability; b) determining and evaluating the impacts of river recreationists on the changing aquatic and terrestrial systems, and c) mitigating such recreational impacts to the extent that natural park values are not compromised.

As mandated by "The Planning Process of the National Park Service in 1975," a Colorado River Management Plan (GCNP 1981) was drafted to guide short-term and long-term management of the riverine and riparian areas of Grand Canyon National Park. Subsequently, a monitoring program was initiated to analyze and quantify human impacts and to determine how changes in management policies influence present resource trends. This monitoring program was designed to gather baseline data and show the impact (adverse and otherwise) of visitor numbers and use patterns on the riparian environment.

Heavy recreational use in other parks has caused changes in the composition of plant species, vegetation density, and diversity (Johnson, et al. 1977). Preliminary data from the Grand Canyon (Atchison, et al. 1979) indicated that similar changes or impacts were taking place on the principal 100-plus campsites of the river corridor. All of these campsites are on alluvial terraces (sand and silt/sand composition) that were deposited during pre-dam floods. In the twenty years prior to 1983, vegetation previously scoured from the beaches on an annual basis proliferated, while human related debris incorporated into beach sands accumulated. With no natural purging of recreation related debris, there exists the potential for popular beaches to fill with various forms of human waste products. Problems of a similar nature have recently been observed in backcountry campsites where recreational use is in excess of the natural purging capacity of the system.

In an effort to improve the quality of the beaches, the Colorado River Management Plan requires that all wood and charcoal carried into the Canyon by river recreationists be burned in fire pans and the ashes be carried out of the canyon. Gas stoves are now required for most cooking purposes. Regulations also require all river users to haul out human wastes.

The flooding which occurred in 1983 cleaned the beaches of the Grand Canyon, resorted the sand, and gave the system a fresh start. Along with this cleansing, new beaches formed and others disappeared. Human impact studies carried out in 1983 established important base line data for future investigations. These data provide the control for subsequent investigations including those carried out in 1992.

Early in 1976, 25 Colorado River campsites in Grand Canyon were selected for the purpose of monitoring levels of recreational impact. In 1980-81, nine additional beaches in the 15 miles of Glen Canyon below Glen Canyon Dam were evaluated for levels of human impact. Since 1976, the original Grand Canyon sites have been monitored and re-evaluated several times (Carothers et al. 1984). In 1982, human impact data for 35 beaches sites in Glen and Grand Canyons were presented and compared with the results of previous sampling efforts. In 1983, human impact data for 22 Grand Canyon beach sites included 17 of the beaches evaluated in 1982 and five new beaches were compared to the 1982 data. Eleven of the original beaches were no longer comparable in 1983 and were dropped from the study. In 1984, two previously studied beaches were not included: however, seven new beaches were added. In the 1992 human impact study 14 beaches were studied; 12 of these beaches were also surveyed in 1991, while two of the beaches were not studied by the 1991 human impact team.

OBJECTIVES

The main objectives of the 1992 Human Impact Study were to:

1) Collect data on the degree of sand discoloration of 14 previously sampled beaches along the Colorado River corridor (1984-1992);

2) Collect data on the incidence of charcoal greater than or equal to 1 cm., and on the incidence of human litter on 14 previously sampled beaches along the Colorado River corridor (1984-92);

3) Compare data collected on sand discoloration, accumulation of charcoal, and accumulation of human litter with the findings from studies conducted between 1984-91 to assess human impact on beaches after they were exposed to flooding in 1983;

4) Collect sand samples to investigate the potential relationship between organic matter produced by tamarisk and sand discoloration.

HYPOTHESES

NULL HYPOTHESIS:
Human impact on selected beaches along the Colorado River corridor has no significant effect on sand discoloration, charcoal accumulation, or litter accumulation.

ALTERNATE HYPOTHESES:
1) Human impact on selected beaches along the Colorado River corridor will result in significant increases in sand discoloration and increases in charcoal and human litter.
2) Sand discoloration on selected beaches along the Colorado River corridor are due to accumulation of organic material from tamarisk plants associated with beaches.

METHODS

1) A 40-meter transect line was run through the principal use area of the beach along the same upstream-downstream line established in previous years. If a 40-meter transect line could not be established, the longest possible line was run and distance recorded. Compass readings, illustrations, and photographs of previous reports were used in locating the transect lines.

2) Black and white photographs of the transect, including the area of the metric tape and river mile marker, were taken from upstream and downstream directions whenever possible. The campsite name, river mile, the side of the river, date and compass reading were written on a chalkboard and included in the photograph (see photographs of previous studies for example).

3) Ten one-square meter plots were laid out equidistant from each other in an alternating pattern along the transect line. When a forty meter transect line could not be established, shorter intervals of equal distance were used. Plots were always numbered 1-10 beginning from the downstream end.

```
        10          8           6          4          2
40   m_____________________________________________0     m
            9           7          5          3          1
                                        DOWNSTREAM
```

4) Each one square meter plot was inspected by hand sifting through the surface sand. All pieces of charcoal greater than or equal to 1 cm., and all pieces of human litter, found in each plot were counted, recorded, and removed. A dry sand sample from the surface of each plot was collected and prepared for analysis by reflectometer.

5) Sand samples were also collected at the following sites: 1)sand /water interface closest to the number one plot; 2) from the terrace above the beach at the old high water line nearest the number 10 plot; and 3) from underneath a mature tamarisk tree on the beach. To obtain sand samples under a tamarisk tree, the area was first scraped to remove excess duff from the surface. Samples were then taken at the following depths: 0 to 5 cm., 5 to 10 cm., and 10 to 12 cm.

6) Each sand sample was sifted through a 150-micron stainless steel mesh apparatus, until the amount of sifted material completely covered the bottom of the container. A wet sample was first dried in a metal tray prior to sifting.

7) Using forceps, a piece of No. 7 coarse-grade filter paper was placed in the lid of the container containing the sifted material with the hatched side exposed. Sifted material was shaken against the filter paper 75 times.

8) The filter paper was removed with forceps and placed in a labeled petri dish for later analysis using a Colorgard II Reflectometer. The shaking apparatus was then cleaned by swirling sand around the inside of the containers and discarding the sand. The wire mesh was cleaned with a toothbrush after each sample was prepared.

9) In addition to samples prepared for analysis by reflectometer, samples of approximately 20 grams in size were collected from each of the above mentioned areas in whirl-packs for later analysis of organic content.

10) The reflectometer was used to obtain reflective values from the filter paper discs which were discolored with filtrate from the sand samples. The reflectometer was calibrated prior to each disc against a white standard of 87.1 percent and a gray standard of 39.9 percent reflective value. The reflectivity of the filter paper was measured and recorded for each of the above-mentioned samples.

11) Means and standard deviations were calculated from reflectometer readings of sand discoloration, charcoal, and human litter. These were then tabulated with the data from 1991. T-score calculations at a 0.05 level of significance were used to compare the 1992 data to the 1991 data.

12) The following procedure was used to determine the percent of organic matter present in selected sand samples from each beach studied:

- A) Part of each sand sample was placed in an oven at 80 F for 48 hours to remove excess moisture;
- B) Five grams of each sample were placed in a crucible and heated over a Bunsen burner for ten minutes;
- C) The sand was allowed to cool for thirty minutes prior to being re-weighed. It was assumed that any loss of weight was the result of organic matter being burned off;
- D) The percentage of organic matter was calculated.

RESULTS

In 1992, eight of the fourteen beaches studied exhibited more discoloration of sand than in the last year they were studied (Table 3-3). Five of these beaches (Badger, Shinumo Wash, Nevills, Lower Lava and Mile 194) had the greatest amount of discoloration demonstrated since the beginning of their analysis (Table 3-3). Thus, over one third of the beaches surveyed exhibited the greatest amount of sand discoloration in 1992. With the exception of Mile 194, analysis of the previously mentioned beaches was begun in 1984. In 1988, Mile 194 was included in

TABLE 3-1 RESULTS OF SAND DISCOLORATION ANALYSIS 1984-92 (MEANS ONLY)

Site No	Campsite Name	River Mile	1984 (S.D.)	1985 (S.D.)	1986 (S.D.)	1987 (S.D.)	1988 (S.D.)	1989 (S.D.)	1990 (S.D.)	1991 (S.D.)	1992 (S.D.)
1	Badger Rapid	8	69.69 (2.52)	70.55 (1.82)	59.65 (5.59)	69.03 (3.95)	68.76 (2.86)	73.42 (1.43)	69.70 (1.94)	62.42 (2.39)	58.8 (2.69)
2	Shinumo Wash	29	69.10 (3.16)	68.62 (3.03)	68.24 (5.14)	72.57 (1.95)	67.42 (3.22)	64.64 (0.69)	70.06 3.43)		64.50 (3.59)
3	Nautiloid	34.7								67.80 (3.65)	62.04 (4.34)
4	Nankoweap	53	64.91 (3.16)	69.33 (2.66)	66.67 (3.51)	71.36 (1.85)	65.67 (2.73)	62.28 (1.73)	70.06 (3.43)	68.42 (2.56)	69.80 (2.00)
5	Nevills	75.5	66.80 (4.87)	72.21 (1.35)	70.94 (2.98)	69.77 (3.12)	67.68 (3.20)	70.98 (2.28)	70.50 (4.03)	65.69 (6.18)	65.1 (2.65)
6	Grapevine	81.1	67.62 (2.18)	67.39 (2.95)	69.38 (3.95)	71.25 (1.04)	67.98 (1.42)	67.15 (0.77)	68.65 (2.09)	68.76 (2.76)	71.4 (2.63)
7	Granite Rapid	93.2	68.48 (3.28)	62.35 (3.50)	68.55 (2.06)	67.52 (1.40)	58.66 (3.47)	54.38 (3.08)		61.46 (4.33)	70.9 (3.00)
8	Lower Bass	108.5	63.38 (5.69)	64.46 (1.69)	68.87 (3.71)	70.31 (3.46)	63.00 (2.56)	61.56 (1.09)	68.71 (3.40)	65.92 (2.25)	71.20 (1.5)
9	Forster	122.8	68.65 (5.16)	69.74 (0.74)	73.27 (1.93)	67.98 (1.43)	66.54 (4.04)	66.29 (1.38)	63.20 (2.03)	67.81 (3.03)	65.99 (3.82)
10	Poncho's	137	65.90 (3.79)	67.20 (3.81)	69.43 (3.04)	69.32 (2.00)	66.35 (2.32)	62.19 (1.46)	68.77 (3.73)	69.58 (1.83)	71.90 (2.20)
11	National	166.6	63.59 (3.00)	67.10 (2.42)	69.23 (1.66)	65.62 (2.17)	66.21 (2.09)	61.63 (0.99)	77.87 (1.43)	72.62 (1.82)	65.66 (1.35)
12	Lower Lava	180		67.74 (1.65)	67.63 (2.92)	72.87 (3.16)	69.43 (1.56)	69.32 (1.45)			66.55 (2.19)
13	194 Mile	194					66.69 (1.56)	71.99 (1.45)	75.24 (1.01)	71.58 (3.45)	65.90 (2.81)
14	220 Mile	220	67.71 ( )	66.93 (2.28)	68.67 (1.74)	69.18 (1.94)	64.97 (1.51)	70.30 (1.91)	65.10 (3.00)		66.37 (2.85)

TABLE 3-2 SAND DISCOLORATION COMPARISON 1991-92

Site No	Campsite Name	River Mile	1991 MEAN	1992 MEAN	STANDARD ERROR	T VALUE
1	Badger Rapid	8	62.42	58.8	1.13	3.2
2	Shinumo Wash	29	(90) 69.5	64.5	1.38	3.62
3	Nautiloid	34.7	67.81	62.04	1.79	3.22
4	Nankoweap	53	68.42	69.8	1.03	1.34
5	Nevills	75.5	65.69	65.1	1.96	0.35
6	Grapevine	81.1	68.76	71.4	1.2	2.2
7	Granite Rapid	93.2	61.46	70.9	1.66	5.66
8	Lower Bass	108.5	65.92	71.2	0.5	10.56
9	Forster	122.8	67.81	65.99	1.54	1.18
10	Poncho's	137	69.58	71.9	0.9	2.58
	National	166.6	72.62	65.66	0.72	9.72
12	Lower Lava	180	(89) 69.32	66.55	0.83	3.33
13	194 Mile	194	71.58	65.9	1.41	4.02
14	220 Mile	220	(90) 65.1	66.37	1.31	0.97

TABLE 3-3 RESULTS OF HUMAN LITTER ACCUMULATIONS 1984-92 (MEANS ONLY)

Site No	Campsite Name	River Mile	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	Badger Rapid	8	0.2	0	0.3	0.4	0.2	0.7	0.1	0.5	0.5
2	Shinumo Wash	29	0.1	1	0.1	0.5	0.1	0.2	0.1		0.1
3	Nautiloid	34.7								O	1.1
4	Nankoweap	53	0.4	0	0	0.8	0.2	0.5	0.4	1.3	1
5	Neville	75.5	0	0	0	0.1	0	0.1	0.2	0.1	0.1
6	Grapevine	81.1	0	0	0	0	0.2	0.4	0.3	0.5	0.2
7	Granite Rapid	93.2	0	0	0.4	0.2	0.6	1.9		1.3	1.6
8	Lower Bass	108.5	2.2	0	0.5	0.6	0.3	1.22	0.3	1	0.6
9	Forster	122.8	0	0	0	0	0	0	0.2	0	0.3
10	Poncho's	137	0.4	0.1	0.8	0.4	0	0.7	0.4	0.4	0.2
11	National	166.6	0	0.2	0.7	0.5	0.1	0	0.3	0.6	0.2
12	Lower Lava	180		0	0.9	0	0.1	0.3			2.9
13	194 Mile	194					0	0	0.1	0	0.3
14	220 Mile	220	0.2	0	0	0.4	0	0.9	0.4		0.3

TABLE 3-4 RESULTS OF CHARCOAL ACCUMULATIONS 1984-92 (MEANS ONLY)

Site No	Campsite Name	River Mile	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	Badger Rapid	8	2.5	0.2	0.2	10.4	5.7	9.6	19	6.9	22.3
2	Shinumo Wash	29	0	0	0	0.6	0.7	0.4	0.5		0.7
3	Nautiloid	34.7								0	0.1
4	Nankoweap	53	0.2	0.6	0.6	6.9	4.8	1.5	4.7	1.1	3.9
5	Neville	75.5	0.3	0	0	0	0.8	0.6	1.1	0.1	0.3
6	Grapevine	81.1	0	0	0	0.5	0.6	0.2		0.8	0.7
7	Granite Rapid	93.2	0	0	0	2.1	0.8	1.08		7.3	4.6
8	Lower Bass	108.5	1.5	0.4	0.5	3.8	3.5	2.67	0.5	0.5	1.5
9	Forster	122.8	0	0	0.6	0	0.2	0.8	0.7	0.2	0.4
10	Poncho's	137	0	0.1	1.3	0.8	0	0.8	0.1	0.7	0.3
11	National	166.6	0	0	0.2	0.3	0.1	0.5	1.1	0.2	0
12	Lower Lava	180		0.7	1.6	3.7	0.5	1.8			2.9
13	194 Mile	194					0.2	0.3	0.5	0.5	0.9
14	220 Mile	220	0.4	0	0	1.4	2.1	1.1	0.7		1.9

TABLE 3-5 COMPARISON OF REFLECTOMETER READINGS

BEACH	MILE	TRANSECT	TERRACE	SAND/WATER	TAMARISK
BADGER	8	58.8	56.7	75.9	65.5
SHINUMO	29	64.5	63.2	74.9	64.4
NAUTILOID	34.7	62.04	60.1	59.7	59.9
NANKOWEAP	53	69.8	66	77.5	71.8
NEVILLS	75.5	65.1	62.7	72	57
GRAPEVINE	81.1	71.4	69.5	71.9	57.5
GRANITE	93.2	70.9	69.1	74	63.5
LOWER BASS	108.5	71.2	66.1	71.7	75.1
FORSTER	122.8	65.99	67		69.4
PONCHO'S	137	71.9	68.8	66	67
NATIONAL	166.6	65.66	64.6	69.1	67.2
LOWER LAVA	180	66.55	63.1	71.5	71.3
194 MILE	194	65.9	71.6	72.6	61.6
220 MILE	220	66.37	61.8	75.3	69.2
MEANS		66.86	65.02	71.7	65.7

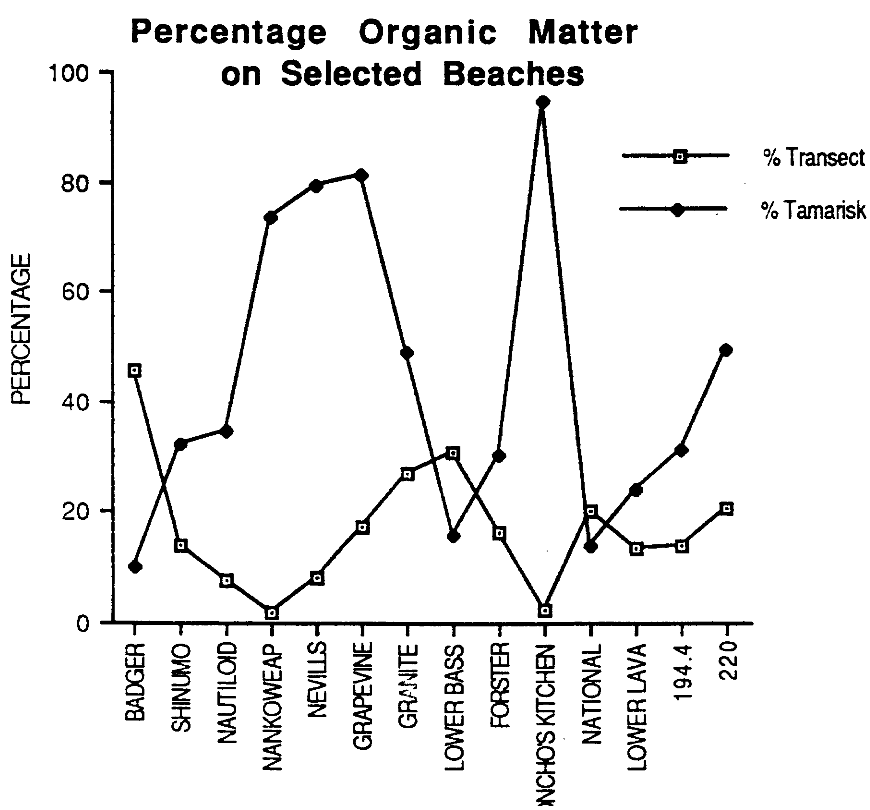


FIGURE 3-2

TABLE 3-6

BEACH NAME: BADGER CREEK
RIVER MILE: 8

SAMPLE #	REFLECTOMETER READING 1991	1992
1	64.9	57.4
2	59.9	62.2
3	63.3	62.0
4	65.5	60.1
5	58.6	56.5
6	60.3	59.9
7	61.4	57.8
8	65.0	61.1
9	62.4	53.6
10	62.6	58.2
MEAN	62.42	58.8
S.D.	2.39	2.69

T-VALUE 3.20

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

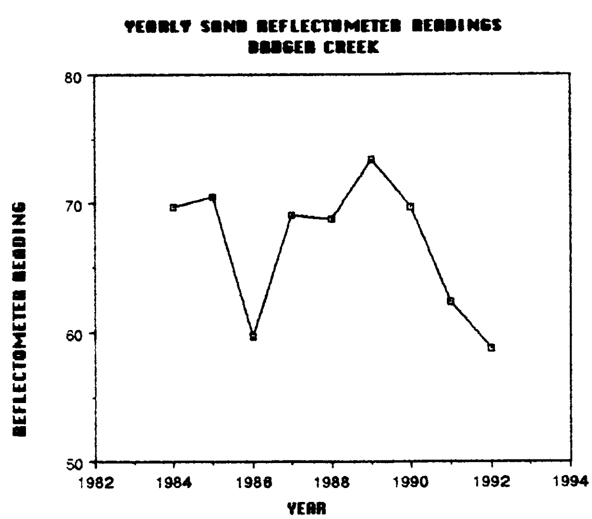


FIGURE 3-6 A

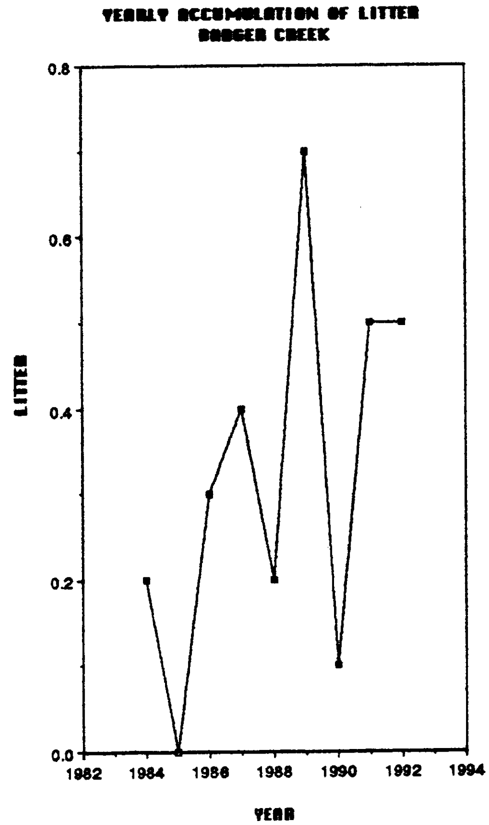


FIGURE 3-6 B

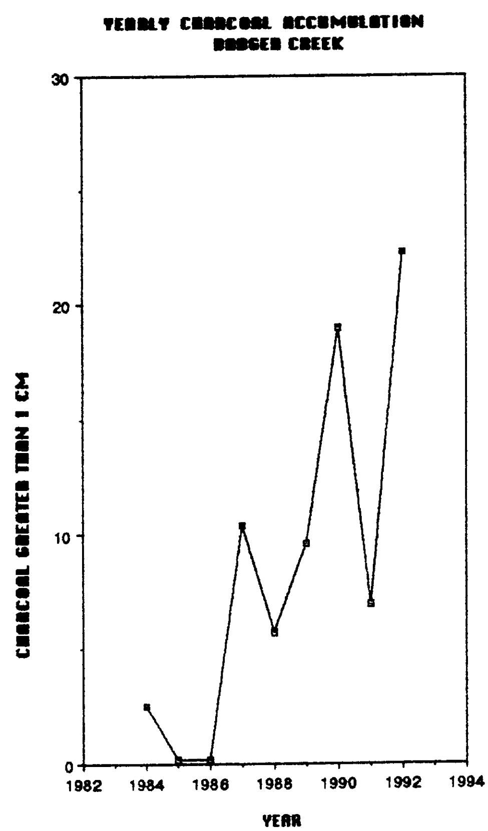


FIGURE 3-6 C

TABLE 3-7

BEACH NAME: SHINUMO
RIVER MILE: 29

SAMPLE #	REFLECTOMETER READING 1991	1992
1		67.5
2		62.6
3		64.6
4		65.7
5		68.9
6		59.8
7		58.4
8		68.0
9		62.6
10		67.3
MEAN		64.5
S.D.		3.59
	T-VALUE	

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

YEARLY SAND REFLECTOMETER READINGS
SHINUMO WASH

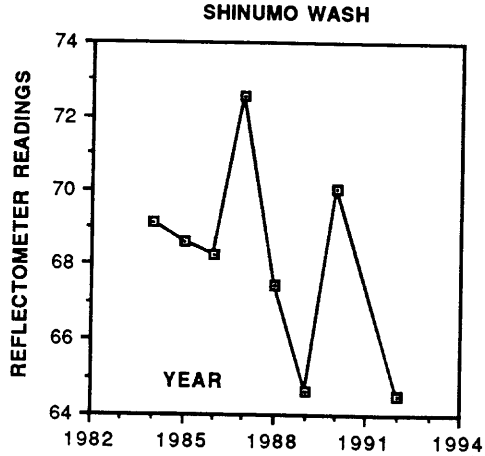


FIGURE 3-7A

YEARLY ACCUMULATION OF LITTER
SHINUMO WASH

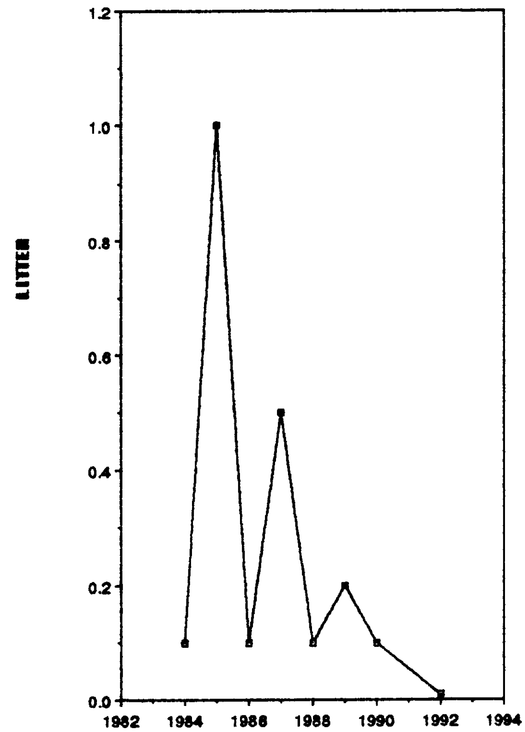


FIGURE 3-7 B

YEARLY CHARCOAL ACCUMULATION
MILE 29

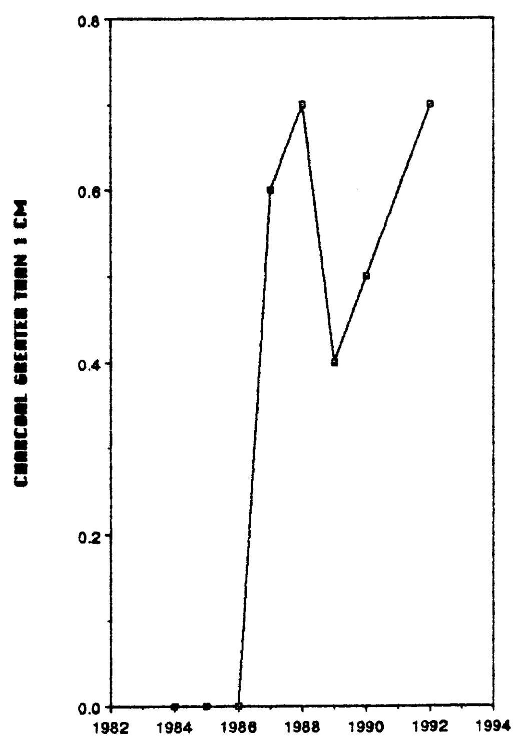


FIGURE 3-7 C

TABLE 3-8

BEACH NAME: NAUTILOID BEACH
RIVER MILE: 34.7

SAMPLE #	REFLECTOMETER READING 1991	1992
1	63.4	59.6
2	66.9	66.5
3	66.5	60.2
4	69.3	63.7
5	65.3	68.5
6	65.1	61.3
7	65.0	55.3
8	69.0	66.1
9	72.6	62.9
10	74.9	56.3
MEAN	67.8	62.04
S.D.	3.66	4.34
	T-VALUE	3.22

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

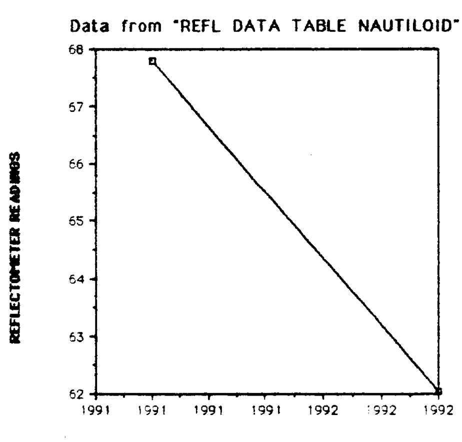


FIGURE 3-8 A

TABLE 3-9

BEACH NAME: LOWER NANKOWEAP
RIVER MILE: 53

SAMPLE #	REFLECTOMETER READING 1991	1992
1	69.1	69.9
2	66.4	71.1
3	68.3	67.1
4	66.8	69.5
5	65.5	70.1
6	70.0	68.9
7	66.8	74.1
8	66.3	69.2
9	72.0	67.4
10	73.0	71.0
MEAN	68.42	69.8
S.D.	3.43	2.00
	T-VALUE	1.34

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

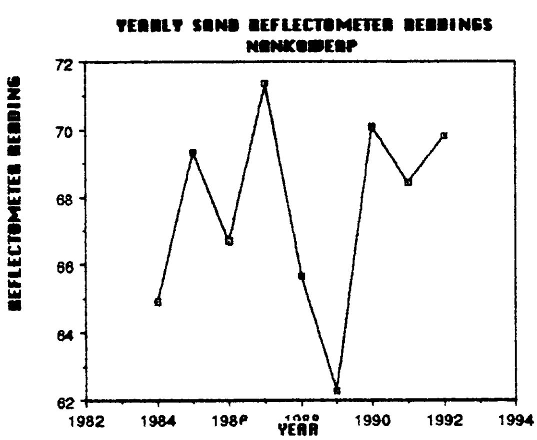


FIGURE 3-9 A

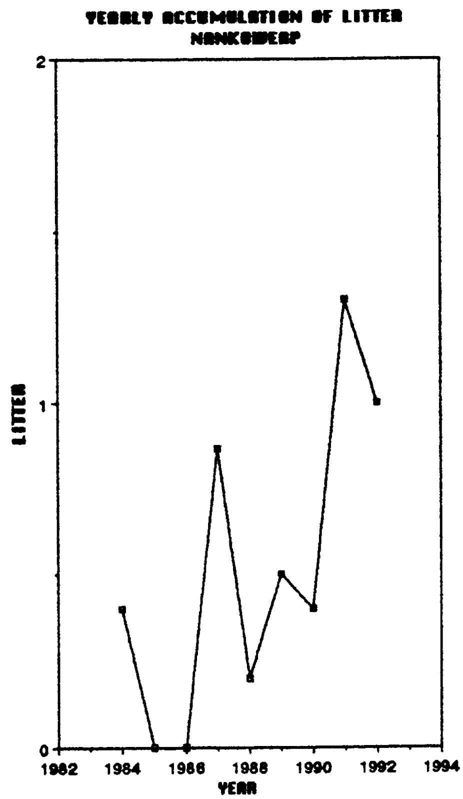


FIGURE 3-9 B

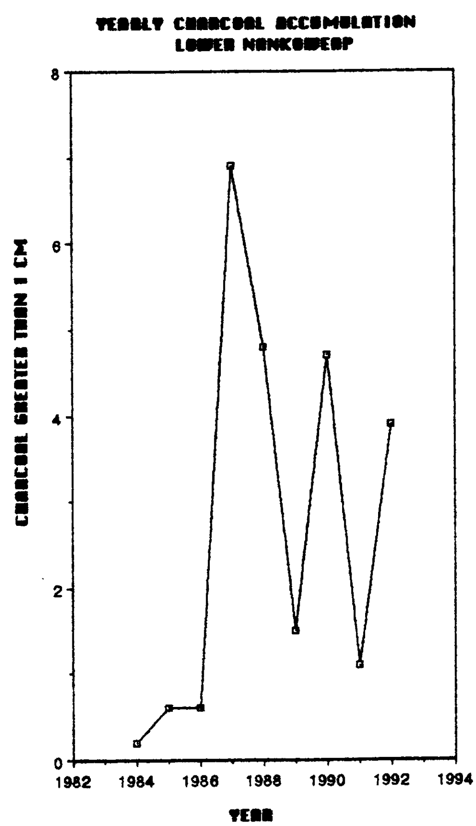


FIGURE 3-9 C

TABLE 3-10

BEACH NAME: NEVILLS
RIVER MILE: 75.5

SAMPLE #	REFLECTOMETER READING 1991	1992
1	68.1	62.4
2	54.9	62.2
3	67.1	63.2
4	70.3	64.8
5	65.0	65.6
6	60.1	70.2
7	64.1	62.6
8	64.8	65.5
9	64.5	67.8
10	78.0	67.1
MEAN	65.79	65.1
S.D.	2.9	2.65
	T-VALUE	0.35

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

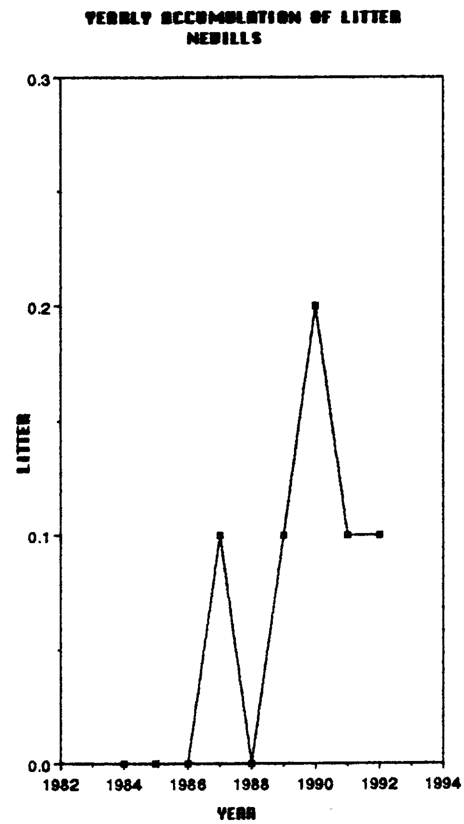


FIGURE 3-10 B

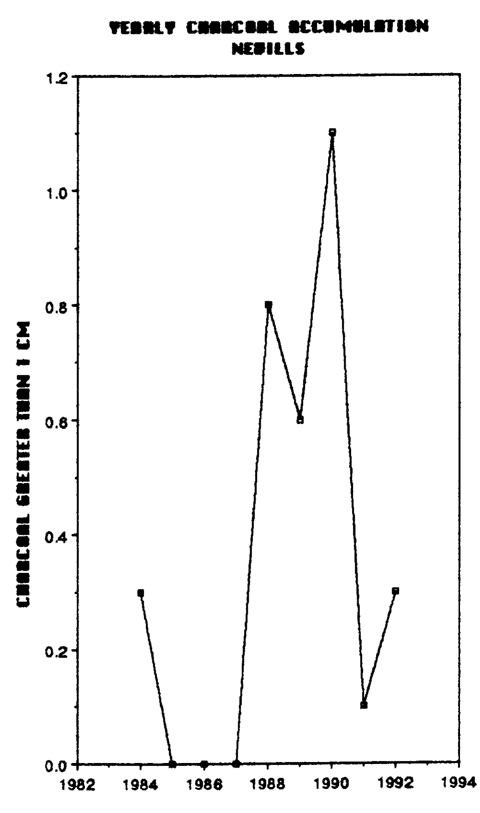


FIGURE 3-10 C

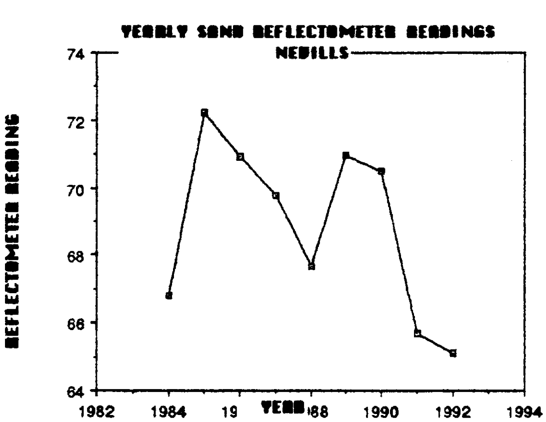


FIGURE 3-10 A

TABLE 3-11

BEACH NAME: GRAPEVINE
RIVER MILE: 81.1

SAMPLE #	REFLECTOMETER READING 1991	1992
1	71.5	72.2
2	69.3	69.8
3	71.6	72.3
4	72.2	73.9
5	69.4	68.9
6	68.0	
7	64.6	73.5
8	69.8	67.8
9	64.7	68.9
10	66.5	75.3
MEAN	68.76	71.4
S.D.	2.76	2.63
	T-VALUE	2.2

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

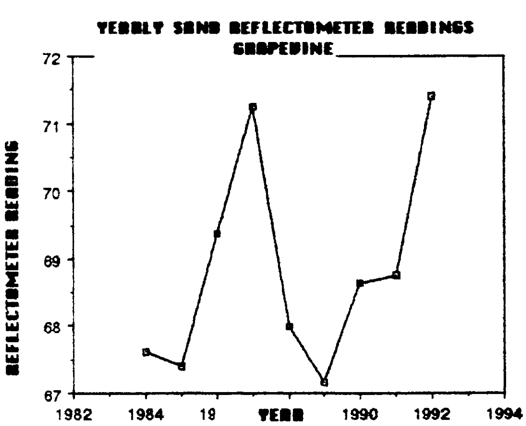


FIGURE 3-11 A

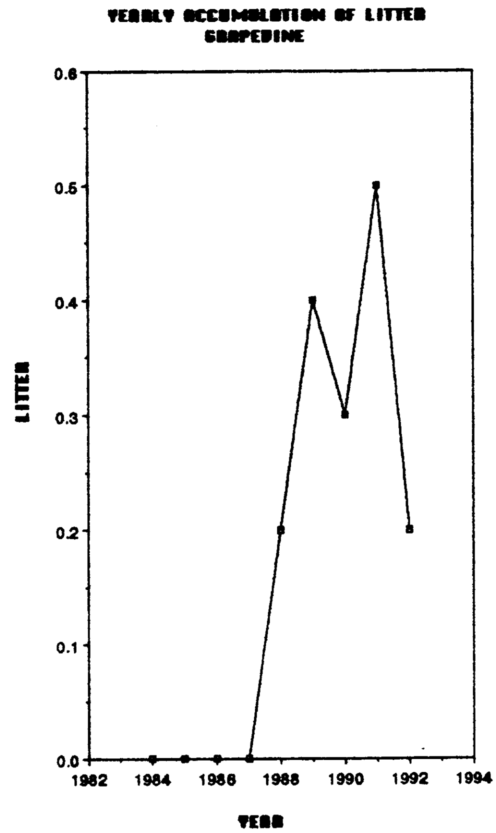


FIGURE 3-11 B

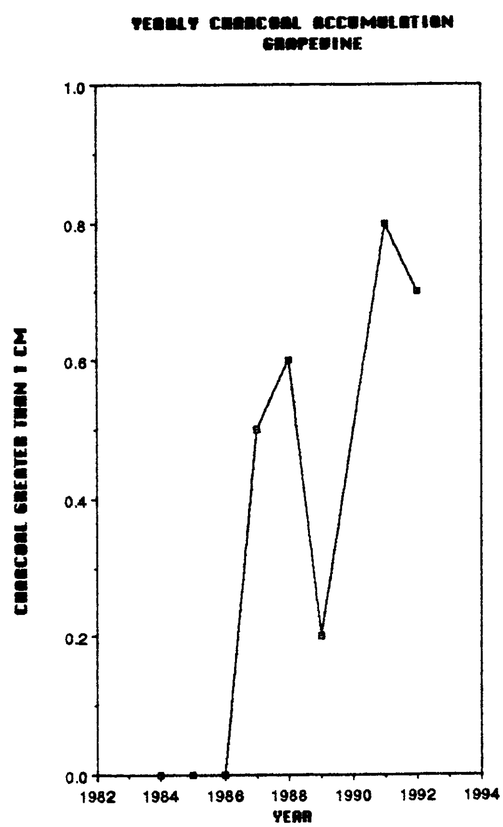


FIGURE 3-11 C

TABLE 3-12

BEACH NAME: GRANITE
RIVER MILE: 92.3

SAMPLE #	REFLECTOMETER READING 1991	1992
1	57.0	67.7
2	59.5	72.1
3	58.6	71.0
4	58.4	65.4
5	64.1	74.1
6	65.9	69.4
7	58.8	70.9
8	70.5	73.3
9	63.3	75.4
10	58.5	70.7
MEAN	61.46	70.9
S.D.	4.33	3.00
	T-VALUE	5.66

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

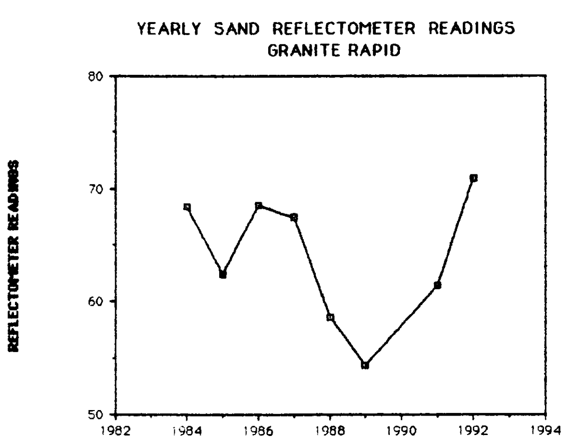


FIGURE 3-12 A

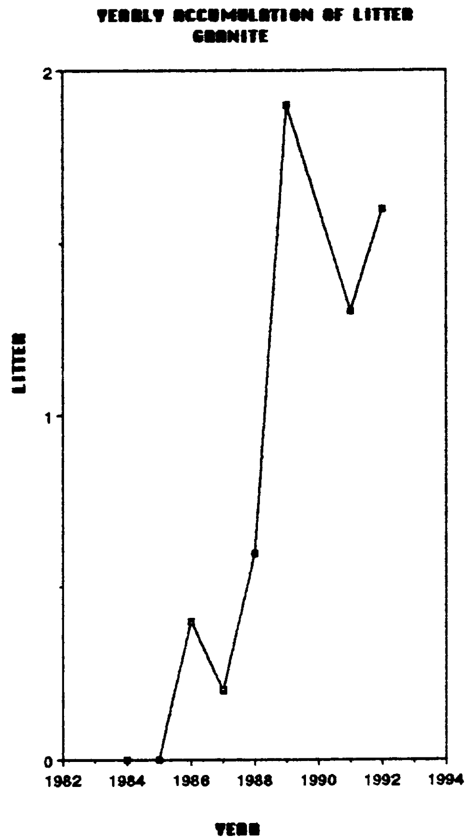


FIGURE 3-12 B

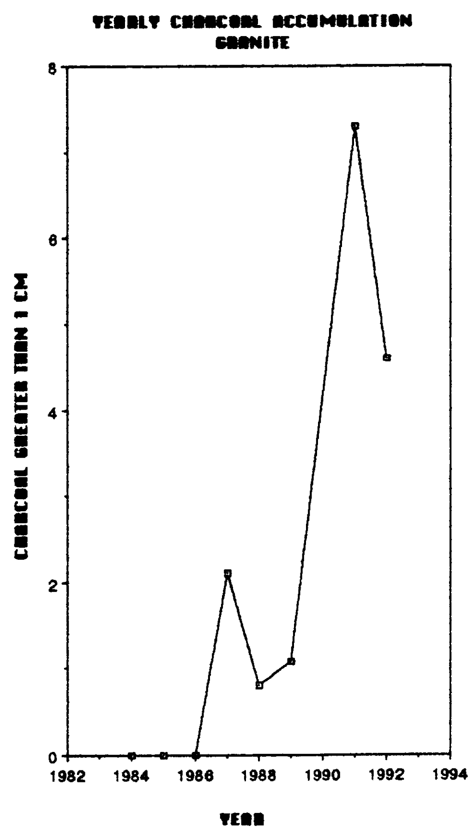


FIGURE 3-12 C

TABLE 3-13

BEACH NAME: LOWER BASS CAMP
RIVER MILE: 108.5

SAMPLE #	REFLECTOMETER READING 1991	REFLECTOMETER READING 1992
1	66.5	73.7
2	67.2	70.2
3`	67.8	70.1
4	63.0	70.4
5	63.9	70.8
6	63.4	69.6
7	66.3	73.1
8	67.6	72.6
9	63.9	72.2
10	69.7	69.7
MEAN	65.92	71.2
S.D.	3.4	1.5
	T-VALUE	10.56

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

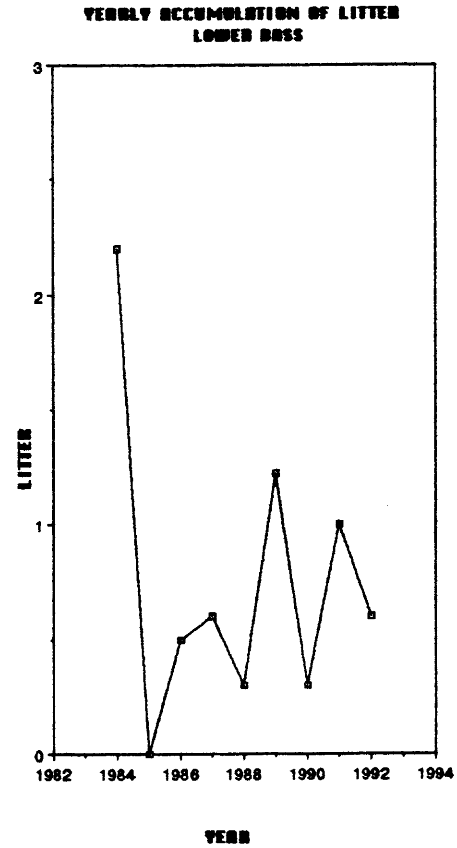


FIGURE 3-13 B

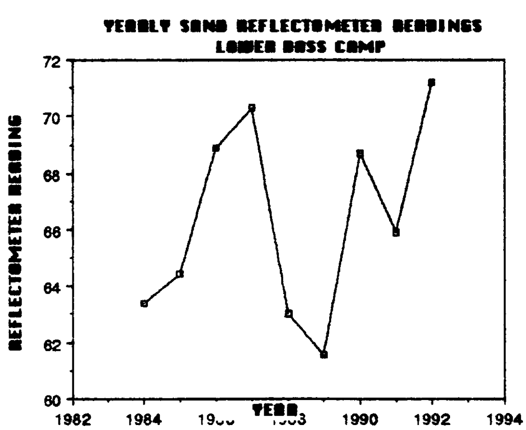


FIGURE 3-13 A

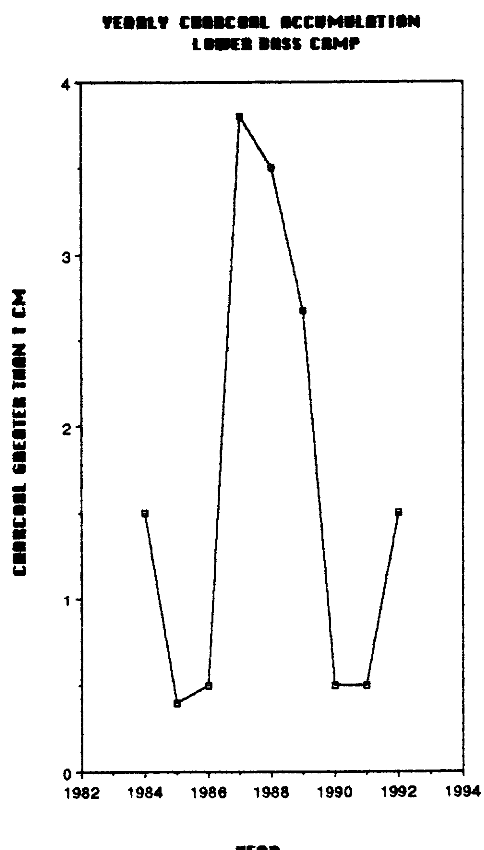


FIGURE 3-13 C

TABLE 3-14

BEACH NAME: FORSTER
RIVER MILE: 122.8

SAMPLE #	REFLECTOMETER READING 1991	REFLECTOMETER READING 1992
1	67.8	65.9
2	69.0	69.7
3	68.7	62.8
4	72.7	69.2
5	71.2	63.1
6	67.7	62.2
7	64.7	68.4
8	62.3	71.9
9	65.6	60.2
10	68.4	66.5
MEAN	67.81	65.99
S.D.	3.03	3.82
	T-VALUE	1.18

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

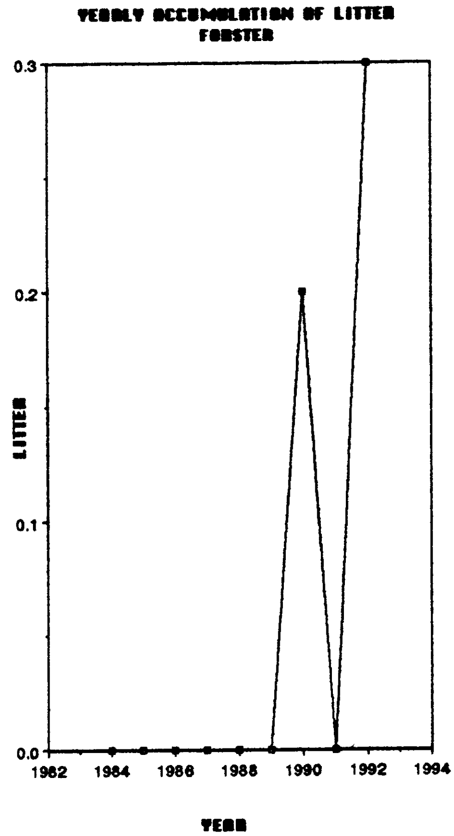


FIGURE 3-14 B

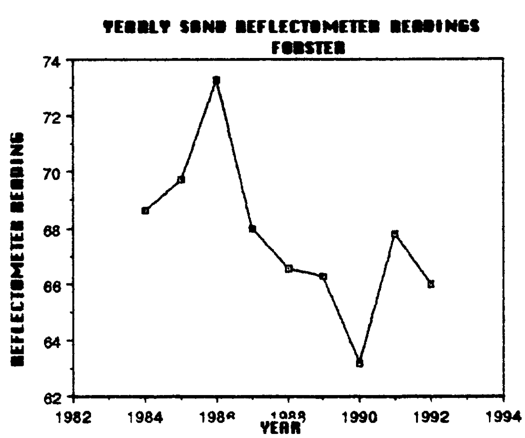


FIGURE 3-14 [illegible]

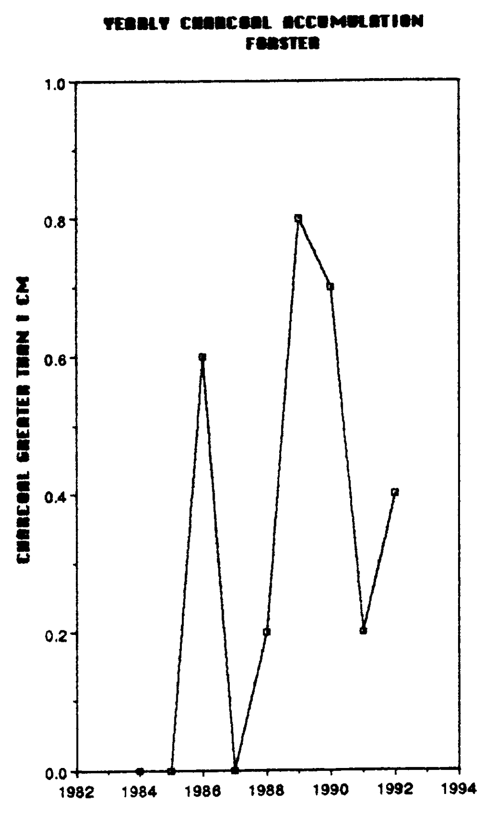


FIGURE 3-14 C

TABLE 3-15

BEACH NAME: PONCHO'S KITCHEN
RIVER MILE: 137

SAMPLE #	REFLECTOMETER READING 1991	1992
1	69.2	70.1
2	71.7	72.7
3	72.9	73.7
4	69.8	73.0
5	67.5	70.0
6	67.5	73.7
7	70.0	69.7
8	68.9	75.9
9	67.6	69.3
10	70.7	71.0
MEAN	69.58	71.9
S.D.	1.83	2.2
	T-VALUE	2.58

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

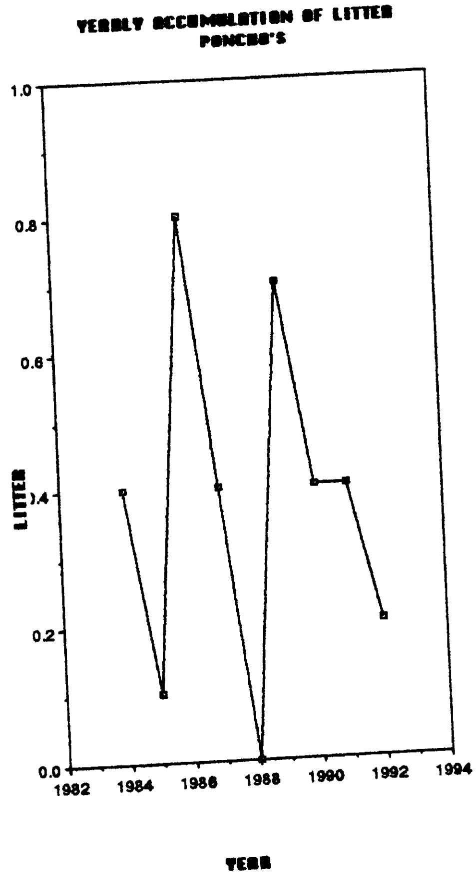


FIGURE 3-15 B

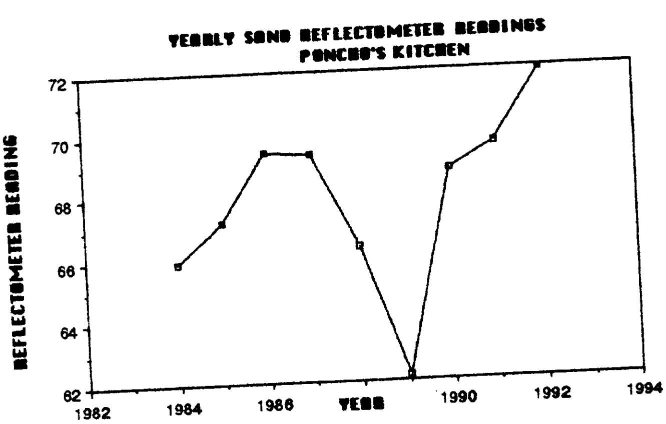


FIGURE 3-15 A

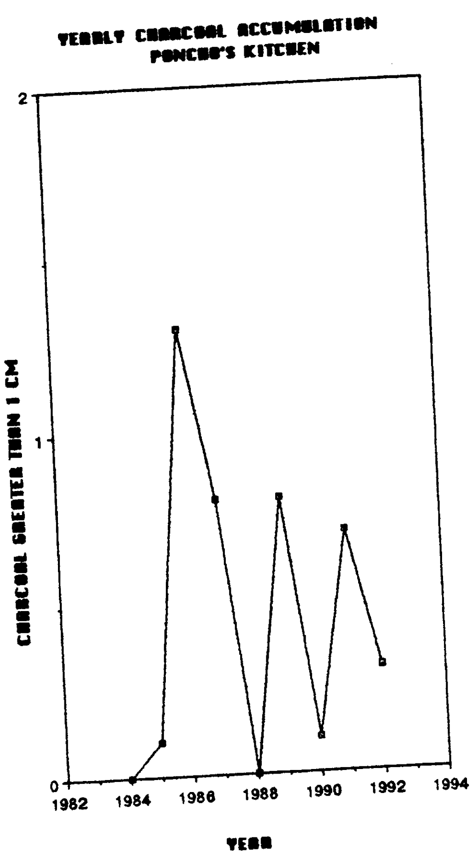


FIGURE 3-15 C

TABLE 3-16

BEACH NAME: LOWER NATIONAL CANYON
RIVER MILE: 166.6

SAMPLE #	REFLECTOMETER READING 1991	1992
1	72.2	67.7
2	74.2	67.2
3	73.2	65.0
4	72.7	65.1
5	70.8	65.8
6	72.4	66.2
7	74.4	63.9
8	72.9	64.1
9	68.7	67.1
10	74.8	64.5
MEAN	72.62	65.66
S.D.	1.82	1.35
	T-VALUE	9.72

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

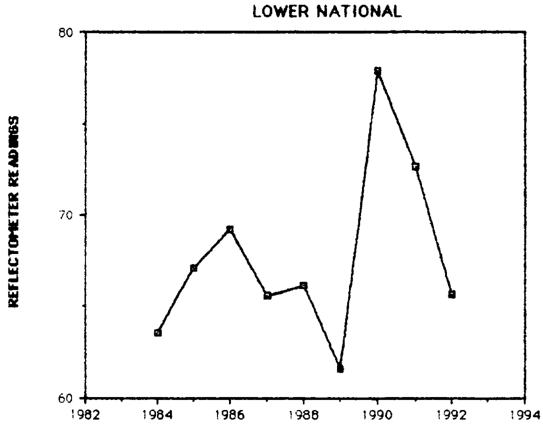


FIGURE 3-8 A

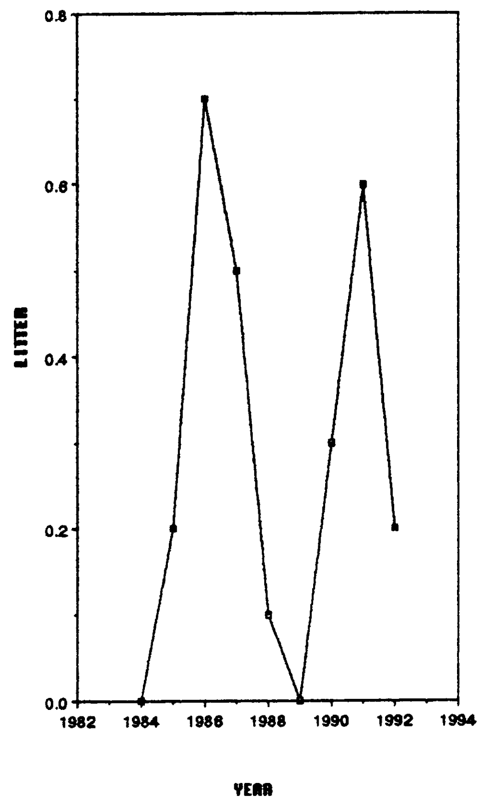


FIGURE 3-16 B

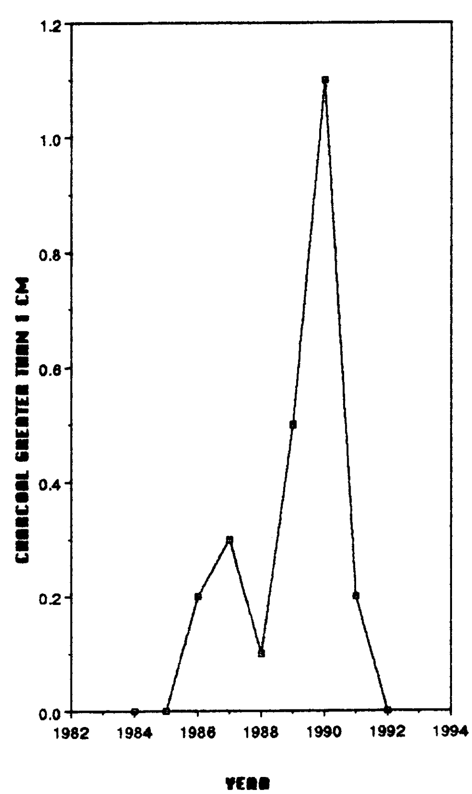


FIGURE 3-16 C

TABLE 3-17

BEACH NAME: LOWER LAVA
RIVER MILE: 180

SAMPLE #	REFLECTOMETER READING 1991	REFLECTOMETER READING 1992
1		67.7
2		62.8
3		66.1
4		68.6
5		69.4
6		68.5
7		65.3
8		65.2
9		67.9
10		64.0
MEAN		66.55
S.D.		2.19
T-VALUE		

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

YEARLY ACCUMULATION OF LITTER
LOWER LAVA

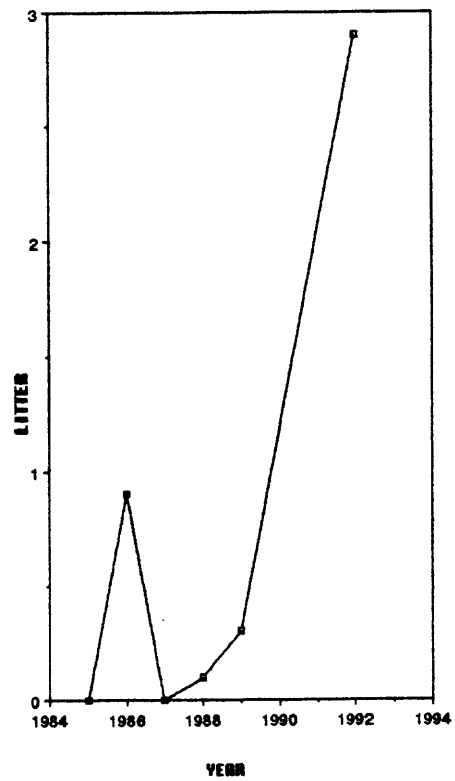


FIGURE 3-17 B

YEARLY CHARCOAL ACCUMULATION
LOWER LAVA

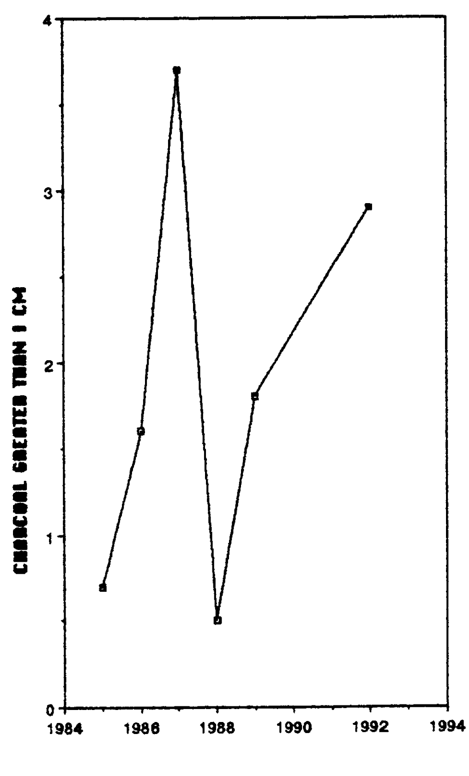


FIGURE 3-17 C

YEARLY SAND REFLECTOMETER READINGS
LOWER LAVA

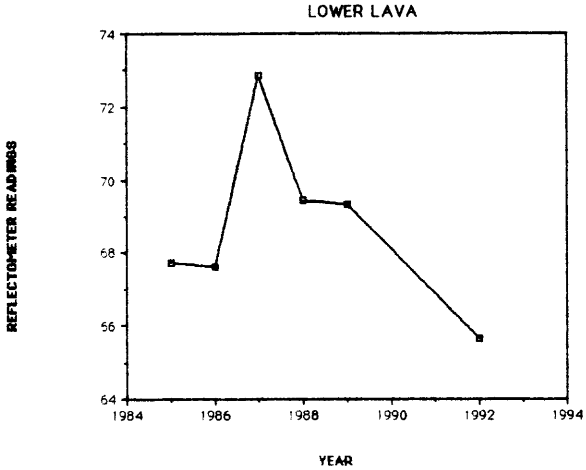


FIGURE 3-17 A

TABLE 3-18

BEACH NAME: 194 MILE
RIVER MILE: 194

SAMPLE #	REFLECTOMETER READING 1991	1992
1	67.4	61.9
2	70.8	67.5
3	75.8	71.2
4	70.5	64.4
5	76.0	66.6
6	73.7	66.5
7	71.9	61.8
8	67.3	66.2
9	67.5	67.9
10	74.9	65.7
MEAN	71.58	65.9
S.D.	3.45	2.81
	T-VALUE	4.02

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

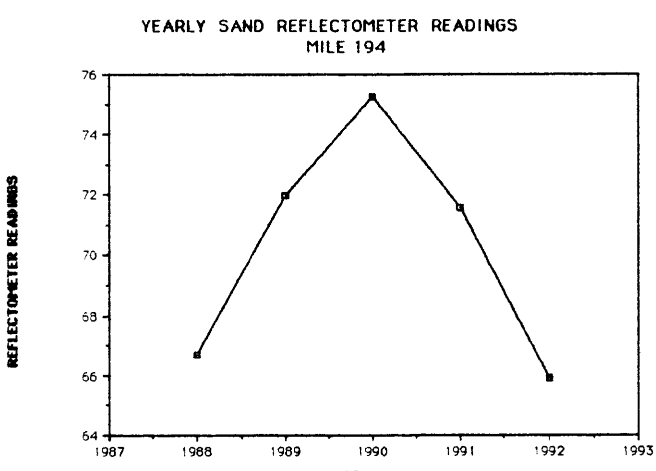


FIGURE 3-18 A

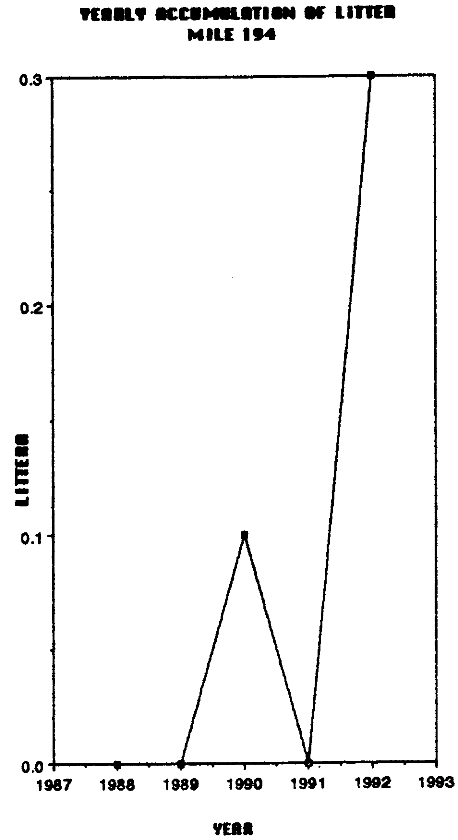


FIGURE 3-18 B

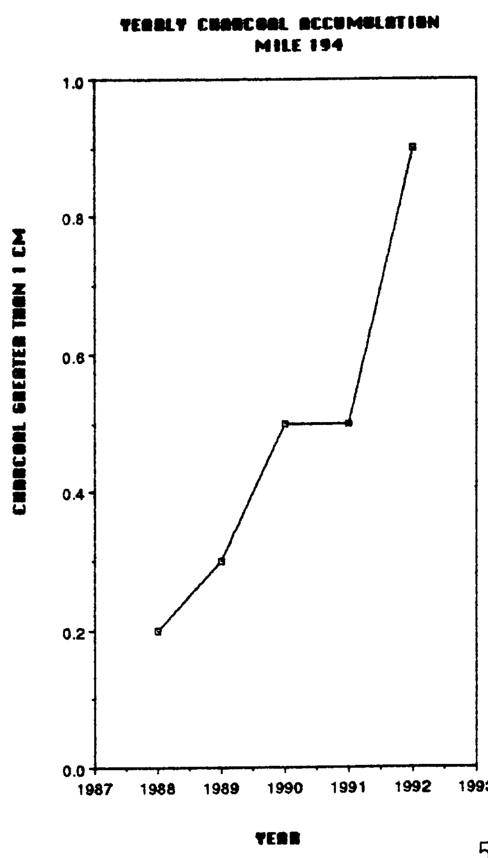


FIGURE 3-18 C

TABLE 3-19

BEACH NAME: 220 MILE
RIVER MILE: 220

SAMPLE #	REFLECTOMETER READING 1991	1992
1		66.3
2		66.3
3		65.8
4		63.1
5		66.7
6		67.7
7		65.6
8		66.8
9		62.4
10		73.0
MEAN		75.3
S.D.		2.85
T-VALUE		

T-VALUE LESS THAN 2.101 AT O.5 LEVEL IS NOT SIGNIFICANT

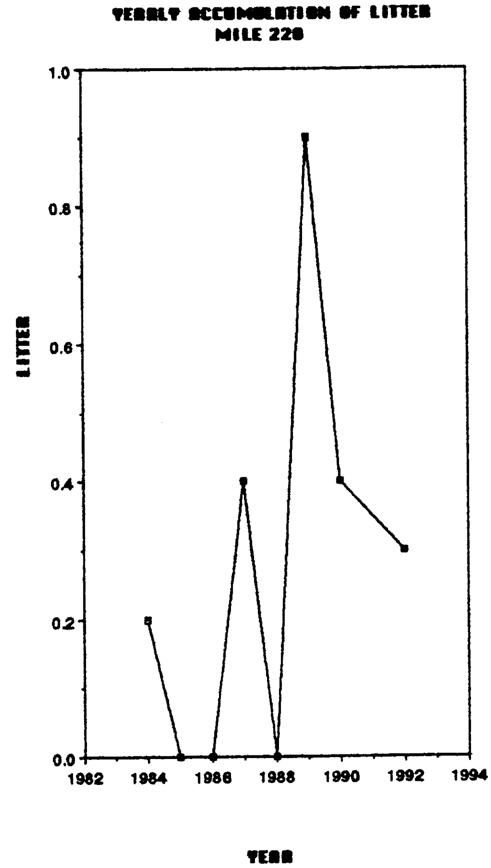


FIGURE 3-18 B

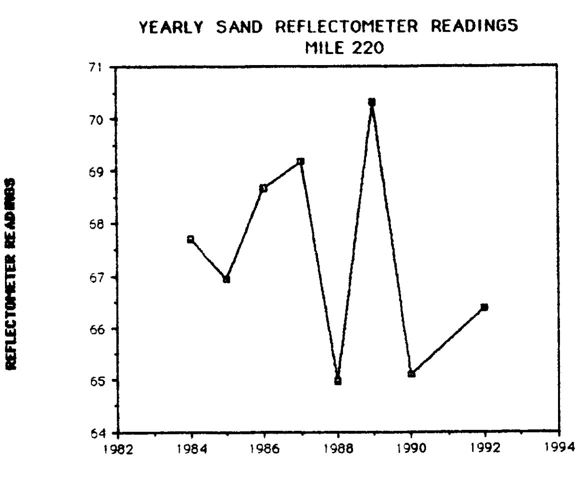


FIGURE 3-19 A

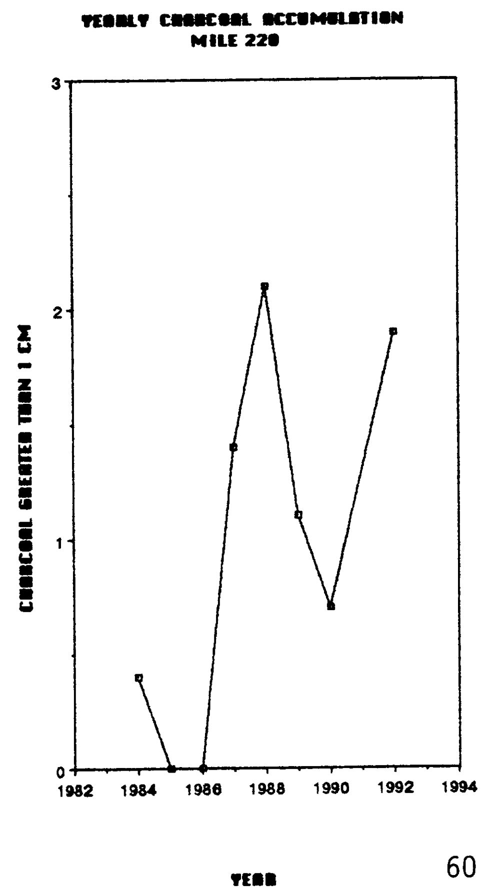


FIGURE 3-18 C

this study. It should be noted that Lower Lava and Shinumo Wash have not been analysed each year (Table 3-3). Badger had the most sand discoloration of any beach studied in 1992 (Table 3-4). Easy access to Badger has resulted in this beach becoming a prime spot for campers and fishermen. Since Badger is not controlled by the National Park Service, and there is no regulation on the number of visitors, the deterioration of this beach is understandable. Although Nevills has more sand discoloration than any previous year, the deterioration of Nevills in 1992 was not significant over that of 1991 (Table 3-1).

Nautiloid has been studied only in 1991 and 1992 (Table 3-2). The deterioration during this period has been significant, going from a reflectometer reading of 67.80 to 62.04 (Table 3-8). In 1992, Lower National had the greatest amount of deterioration of all the beaches from the previous study (Table 3-16). This beach had the second highest amount of sand discoloration, surpassed only by Badger (Table 3-4). Lower National showed a great improvement in discoloration in 1990 but has been on the decline since 1990 (Table 3-1 and Figure 3-11). The 1992 reading of 65.66 is approaching its lowest reading of 61.63 recorded in 1989.

Forster has a general pattern of deterioration. In the years of 1986 and 1991 this beach did exhibit cleaner conditions. However, the 1992 reflectometer reading of 65.99 is approaching the lowest recorded reading (1990) of approximately 63.25. (Table 3-1 and Figure 3-9).

National is also deteriorating. In 1990, this beach had a high peak reflectometer reading of 77.9, indicating the cleanest condition since it has been studied. However, deterioration has occurred during the past two years and the 1992 reading of 65.66 is approaching the 1989 reading of 61.63 which is the lowest reading this highly used beach has ever exhibited.

On the plus side, four beaches (Grapevine, Granite Rapid, Lower Bass, and Poncho's Kitchen) showed a significant improvement in cleanliness of sand over 1991. All four of these beaches had the highest reflectometer readings they had ever recorded, indicating they are the cleanest they have been since the beginning of this study in 1984 (Tables 3-11, 3-12, 3-13, 3-15 and Figures 3-6, 3-7, 3-8, 3-10). Mile 220 was not studied in 1991; however, it demonstrated a non-significant improvement over the 1990 study (Table 3-19, Figure 3-14). Mile 220 has been inconsistent, but its general condition appears to be deteriorating (Figure 3-14).

Most of the beaches studied exhibited the cleanest sand at the water interface (Table 3-5). Nautiloid and Poncho's Kitchen were the only two beaches to differ from this trend. Although Nautiloid did have a lower reading at the sand/water interface, this reading was not statistically significant. The lower reading at Poncho's Kitchen may be attributed to the fact that a flash flood had occurred two days prior to our analysis. The beach was still littered with debris from this flood.

None of the beaches showed a significant increase in human litter (Table 3-3). Only three beaches (Badger, Nautiloid and Lower Bass) showed an increase of charcoal accumulation over the last study. Badger and Nautiloid both exhibited a significant deterioration in sand discoloration, while Lower Bass had the most significant improvement in sand discoloration (Table 3-4). This indicates that charcoal may not play a major role in sand discoloration. For a comparison of charcoal accumulation, human litter, and sand discoloration see Table 3-6 through Table 3-19.

Duff from tamarisk trees does not appear to have any effect on sand discoloration (Table-5 and Figure 3-2). Grapevine, Granite Reef, Poncho's Kitchen and Lower Bass have the four highest reflectometer readings, indicating that they have the cleanest sand of all the beaches studied (Table 3-4). Grapevine, Granite Reef and Poncho's Kitchen also exhibited the highest percentage of organic matter in sand collected under tamarisk (Figure 3-8). Lower Bass was the only beach with cleaner sand to show a low percentage of organic matter. Since no previous studies have been done on the relationship between sand discoloration and tamarisk trees, a follow up study might be conducted to verify these preliminary findings.

CONCLUSIONS

The 1991 and 1992 Human Impact studies indicate that the quality of the beaches of the Colorado River in the Grand Canyon appears to be declining. This 1992 study notes that the most deterioration has occurred at Badger where there is no regulation on the number of visitors. The cleanest section of the beaches is at the beach/water interface. This may be the result of scouring by changes in water level. Even though the amount of charcoal accumulation decreased from the previous year, the overall pattern for this eleven year study indicates that there is an upward trend in accumulation of both charcoal and human litter. Three of the beaches studied in 1992 recorded the least amount of sand discoloration since the start of this study. Two of these three beaches are also heavy use beaches. This appears to contradict the hypothesis that sand discoloration is due to human use. The reason for this contradiction may be the result of the most popular beaches being occupied by commercial boatmen, while private parties are left with the less desirable beaches. There does not appear to be a relationship between sand discoloration and accumulation of plant matter. Although further research is needed before conclusions can be reached, this initial study may support the hypothesis that sand discoloration may be the result of accumulation of body oils and suntan lotion instead of plant matter.

Results are still not clear. The overall conditions of the beaches appear to have declined during the years of this study. However, they still are much cleaner than the pre-regulation conditions observed by Steven W. Carothers et al. in the " Recreational Impacts of Colorado River Beaches in Glen Canyon Final Report 14 August 1981".

RECOMMENDATIONS

Sand discoloration may be affected by the type of usage the beach is receiving instead of the number of visitors. It is recommended that a comparison of the condition of beaches and predominant usage by commercial rivermen and private boaters be conducted. It is also felt that sand should be analysed in the laboratory for body oils and/or traces of suntan lotion.

Further studies on the relationship between accumulation of plant matter (especially tamerisk tree duff) be conducted. The method of collecting samples for analysis of organic matter should be refined. To reduce the risk of contamination, it is suggested that a borer be used to collect samples at uniform depths of five, ten, and twelve centimeters.

Photographs of the beach should be taken each time it is studied. These photographs should be kept on file and compared over the years for changes in conditions, especially growth of plant matter. The team should have access to a photographer. One photographer for all sections of the COLORADO RIVER INVESTIGATION is not enough. There were several times when the photographer was on a different boat and therefore did not even stop at the beach that was being studied. These photographs should also be used to enable further researchers to locate the identical transect line in subsequent years.

EQUIPMENT LIST

RIVER TRIP

Brunton compass (quadrant type)
Reflectometer II + battery: (extra battery)
500 - 100 small whirl packs
Transect line (40 meter tape)
2 magic markers (waterproof)
3 - one square meter frames, collapsible
5 plastic sand sifters
filter paper (#7 coarse grade) 15 per beach
2 tweezers (to pick up filter paper)
2 toothbrushes (to clean stainless steel mesh apparatus)
15 large sample bags (to store and carry samples)
5 - 150 micron stainless steel mesh apparatus
1 table with legs
calculator with statistical mode
pad for writing, pencils, pencil sharpener
black and white film camera
umbrella
previous year's beach sand report, including data sheets of each beach
photos of previous year's transect lines
2 pairs scissors
2 drying pans
epoxy glue to repair mesh screens
spare mesh screen

LABORATORY EQUIPMENT

computer diskettes
table of T-scores
blank data sheets
computer program to calculator T-scores
previous year's report and tables on Macintosh diskettes
crucibles
tongs
rings, ringstands
ceramic triangles
Bunsen burners
digital balance
copy of Colorado River Management Plan 1981
current figures of human use on Grand Canyon National Park

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CHAPTER 4

SOCIOLOGICAL DATA REPORT

NORM GEIGER

INTRODUCTION

Each year the National Park Service issues permits for some 16,500 people to travel through the Grand Canyon. This translates into about 150 commercial and 16 to 32 private individuals putting on the river on any given day. The progress of these groups is not monitored or controlled. Consequently, the Park Service has no data for determining the frequency of contact between these various groups.

This report continues the Colorado River Investigations Sociological Data which was begun in 1982. This is the only quantitative study information regarding human contacts within the river corridor, and how those contacts affect the quality of Park visitors river experience. Hopefully the Park Service will review these reports in order to better protect the quality of of a Grand Canyon river trip.

METHODS

The Grand Canyon Experience researchers travelled on two 37 ft motor rigs from Lee's Ferry to South Cove on Lake Mead. The trip lasted from July 19 to July 29, 1992. All human contacts were recorded beginning with the group's arrival at Lee's Ferry and continuing until Diamond Creek, which has been the traditional take-out for this program. Contacts were recorded all the way to South Cove just for interest value. In addition, all stops the group made were recorded as to the day, time, river mile, and beach name (if available) and purpose. All departures were recorded as to the day, time, river mile and beach name. All contacts with other boats, with aircraft or with hikers were also recorded by day and time and number of people encountered. Aircraft were identified visually and/or aurally. Of course, in the case of aircraft, people are not visible and therefore cannot be counted. Any pedestrian encountered during research activities or at attraction sites were counted as hikers, even though they may have been derived from a commercial or private float trip. All repeat contacts with boats were counted again.

At times, the two boats in the research party separated to pursue different purposes. At this time, the researcher simply recorded human contacts as they occured to his boat and made no attempt to document the contacts experienced by the other boat. This is because the researcher felt that the data should reflect human contacts experienced by a single visitor travelling the river as a commercial passenger (motor boats, professional guides, pre-assigned camps, no responsibilty for camp chores, etc).

Upon return, the Grand Canyon Experience participants completed a simple attitude survey to try to define which contacts were viewed as the most disturbing. This survey and its results are shown in supplement 4-1.

RESULTS

From Lee's Ferry to Diamond Creek, the researcher counted 1275 contacts with other humans. This is about 128 people every day. 125 of these people were on foot (the majority near Phantom Ranch and Havasu Canyon) and the rest were in the 240 boats encountered. In addition to these contacts were 335 aircraft identified. This reflects a 15% increase over 1991 records. All contacts, including boats and aircraft, are tabulated in tables 4-2. Tables 4-3 and 4-4 compare the different types of boats and aircraft contacted. In addition, aircraft contacts were graphed by type and day, and boat contacts were graphed by type and day (see figures 4-1, 4-2, and 4-3).

Most participants experiened frustration with hikers derived from other commercial boat trips. Aircraft were often easy to ignore, and encounters with other boats en route were usually transient. Of course, the group did not experience the controlled 5000 cfs flow that was so frustrating in 1991. This group also did not experience as much campsite competition because the two boats sometimes separated, allowing one to motor downstream to secure camp early.

SUMMARY

In a place as popular as the Grand Canyon, human contacts are bound to happen. Purists would argue that National Parks are no place for commercial activities (overflights and commercial boat trips), but this is of course unrealistic. Many people visit the Canyon solely to partake in these activities, and it is their interest and money which helps the Park Service to manage the Canyon in an intelligent fashion. A person

TABLE 4-1: Log of stops made, GCE river trip 7/19-1/29/92.

DAY	MILE	BEACH	REASON	TIME
1	0	Lees Ferry	arrive	10.4
1	0	Lees Ferry	depart	11.38
1	8	Badger	beach research	13.08
1	19.3	19.3 mile	B.R. camp	16.32
2	19.3	19.3 mile	depart	8.06
2	20	North Canyon	B.R. hike	8.2
2	24.5	24.5 mile	lecture	10.2
2	29.2	Silver Grotto	B.R.	11.06
2	33.1	redwall grotto	wait	12.47
2	34.7	nautoloid canyon	b.r., lunch	13.39
2	50	dino camp	camp	17.5
3	52	nankoweap	b.r., hike	8.04
3	58.1	awatubi	transfer gear	11.34
3	61.1	little colorado	rad sample	12.17
3	64.6	carbon	b.r., camp	13.21
4	64.6	carbon hike	depart on hike	7.25
4	65.5	lava canyon	meet boats	10.15
4	75.5	nevills	lunch	11.35
4	81	grapevine	b.r.,camp	14.03
5	87.5	phantom/bright angel	phone/mail	8.56
5	93.2	granite	b.r.	10.55
5	108.3	bass	b.r.	15.09
5	108.6	shinumo	pleasure	15.26
5	116.5	elves chasm	rad sample	17.15
5	120.1	blacktail	b.r., camp	18.03
6	122.8	forrester	b.r.	9.05
6	136.1	deer creek	pleasure	11.16
6	136.6	panchos kitchen	b.r., camp	17.07
7	143.5	kanab creek	rad sample	8.47
7	148	matkatamiba	pleasure	10.16
7	156.9	havasu	pleasure	12.01
7	166.5	national	b.r., reports	1601
8	166.5	national	layover	all day
9	180	lower lava	b.r.	10.49
9	194	194 mile beach	b.r., lunch	13.29
9	216	216 mile beach	camp	18.15
10	220	220 mile beach	b.r.	9.15
10	226	diamond creek	end of count	10.55
10	229	travertine falls	lunch, pleasure	11.25
10	265	duffy's camp	camp	18.29
11			motor out	

TABLE 4-2: Total human contacts by day and type.

day	boats	aircraft	hikers	# of people
1	37	1	3	214
2	17	10	0	46
3	27	110	3	120
4	10	58	0	44
5	46	15	57	307
6	18	4	35	147
7	41	14	27	186
8	0	82	0	0
9	44	37	0	211
10	0	4	0	0
totals	240	335	125	1275
av./ day	24	33.5	12.5	127.5

TABLE 4-3: Boat contacts by day and type.

DAY	Commercial Motor	Commercial Row	Private Motor	Private Row	DAILY TOTAL
1	5	28	0	4	37
2	0	5	0	12	17
3	3	0	0	24	27
4	1	0	0	9	10
5	18	0	0	28	46
6	15	0	0	3	18
7	17	0	0	24	41
8	0	0	0	0	0
9	8	24	0	12	44
10	0	0	0	0	0
Total	67	57	0	116	240

TABLE 4-4: Aircraft contacts by day and type.

day	fixed wing	rotating wing	high altitude jet	daily total
1	1	0	0	1
2	5	0	5	10
3	76	21	13	110
4	49	3	6	58
5	10	3	2	15
6	2	2	0	4
7	14	0	0	14
8	80	0	2	82
9	35	1	1	37
10	4	0	0	4
totals	276	30	29	335
% of totals	82	9	9	

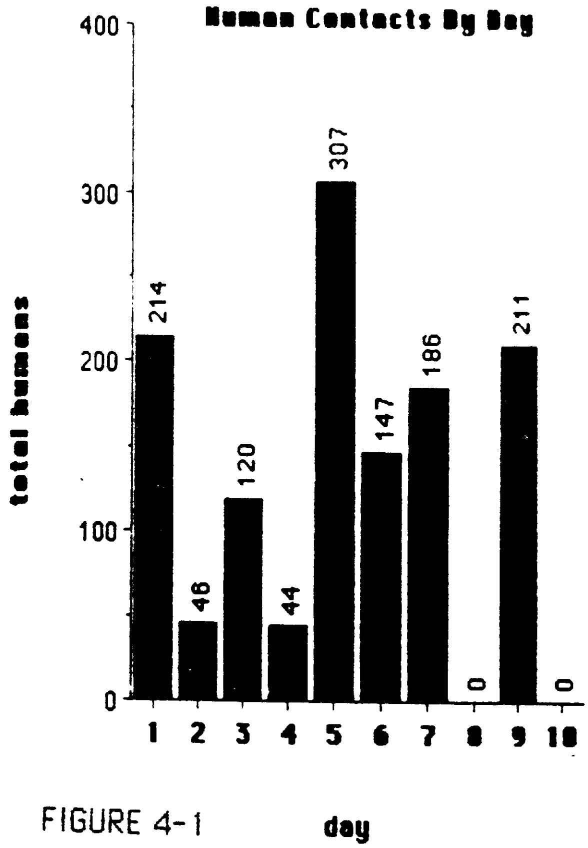

FIGURE 4-1

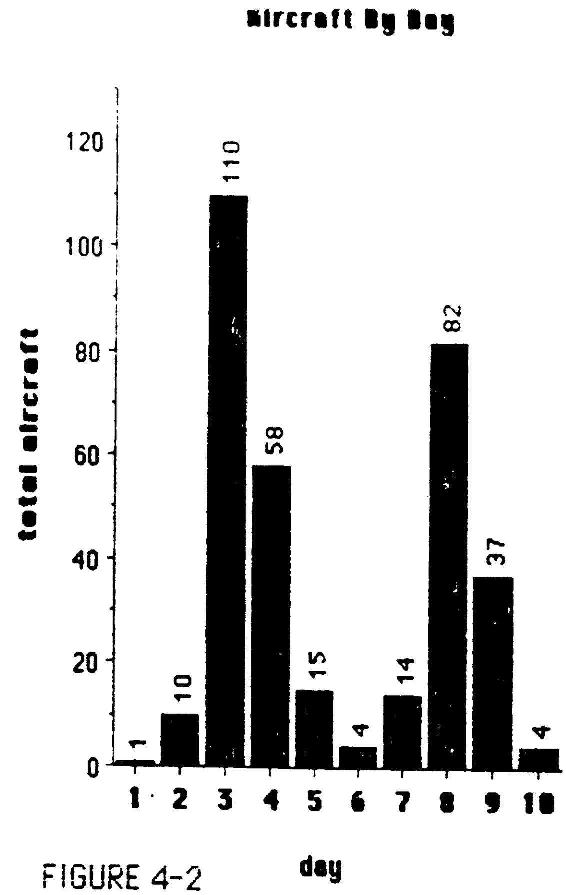

FIGURE 4-2

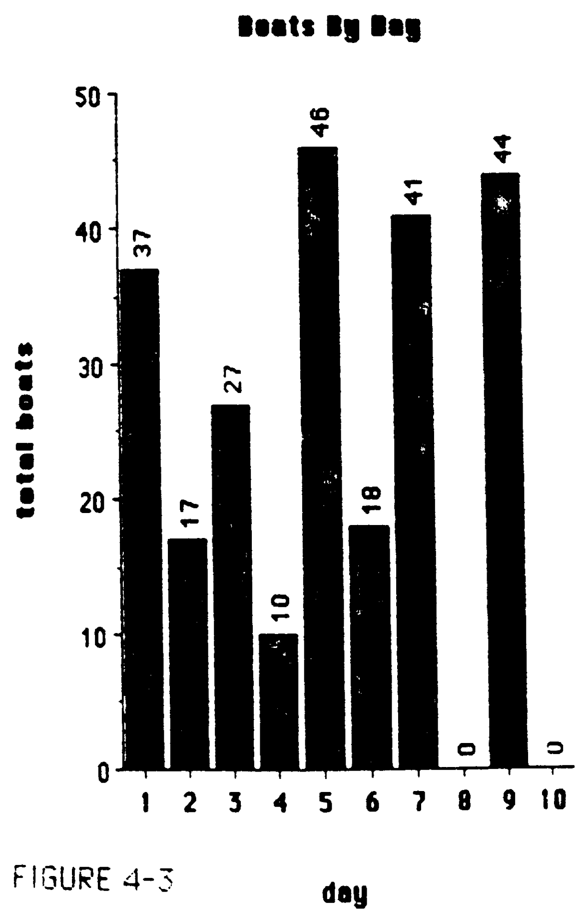

FIGURE 4-3

who intends to visit the river corridor should be well-enough informed to know that it is a popular place, and that they should make their own opportunities for solitude. Know how many people do visit the Canyon every year, it seems more important that visitors work together to protect the inner Grand Canyon from human impacts than to expect it to provide a pure wilderness experience.

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CHAPTER 5

TEMPERATURE AND HUMIDITY GRADIENTS OF SELECTED BEACHES ALONG THE COLORADO RIVER BETWEEN LEE'S FERRY AND THREE SPRINGS RAPID

David Komoto and Viki Hughes

INTRODUCTION

Temperature and moisture (relative humidity) are two important abiotic factors that influence the diversity, density and distribution of the flora and fauna within an ecosystem. On the beaches in the Grand Canyon Corridor, there are distinct habitats or zones from the river's edge to the talus slope, with each zone having specific types of vegetation. In this study, we attempt to determine if the distance from the river's edge and the degree of slope on the beach have an effect on the temperature and humidity of the area. Also, we present data on cloud cover, cloud type, wind speed, soil moisture and water temperature.

Studies were conducted at eight different locations (with a two day study at National Canyon), at the campsites occupied by the NAU Geology/Biology workshop members for their Grand Canyon Experience research projects. We hypothesize that there are temperature and humidity gradients due to the thermal insulating effects of the river, that temperatures will increase from Lee's Ferry to Lake Mead due to the almost 1900 feet decrease in altitude, and that the water temperature will gradually increase as the water proceeds down the river.

METHODS

A. Materials

1. 8 maximum/minimum thermometers
2. 8 wooden stakes (4' X 2" X 2")
3. 2 sling psychrometers
4. 2 mercury thermometers
5. hygrometer
6. barometer

7. soil moisture meter
8. wind gauge
9. 3-ring binder
10. data sheets
11. pencils
12. 3 permanent markers
13. ammo can
14. hammer
15. screwdriver
16. 50 ft. tape
17. 2 bungee cords

B. Procedure

1. Wooden stakes were set up in a line perpendicular to the river. They were spaced in 10 meter intervals beginning with the river's edge and continuing up to the edge of the talus slope. A maximum/minimum thermometer was placed on each stake, approximately 4 feet above the ground. The thermometers were calibrated and the initial temperatures were recorded. This was generally done before 8:00P.M. Maximum and minimum temperatures were taken each morning and removed around 7:00A.M. On one occasion the thermometers were left for a two day period.

The following were also measured at the time of set up:

2. Relative humidity was measured at the river's edge and the talus slope. This was done using a sling psychrometer and a hygrometer.
3. Soil moisture was measured using a plant moisture meter at various locations, including the river's edge and the talus slope.
4. The wind speed on the beach was determined by using a wind gauge.
5. The slope of the beach was determined by taking eye-height measurements with a Brunton compass.
6. The water's temperature was taken with a mercury thermometer.
7. Cloud cover was observed and recorded.

RESULTS

The data collected at the eight different locations indicate that there are temperature differences between the river's edge and the edge of the talus slope. All temperatures were measured in degrees Fahrenheit. Generally the temperature, both maximum and minimum, increases as one goes up the beach, creating a fairly constant temperature gradient. The greatest minimum temperature change between the river's edge and the talus slope was an increase of 18° at Carbon Creek and a maximum change of 12° at National Canyon.

The least minimum and maximum changes were both 2° at National Canyon and 3 Springs Rapid. The overall average temperature change between river's edge and the talus slope was 6°. Five of the nine recordings for maximum temperature showed increases, while eight of the nine minimum temperatures showed increases. The minimum temperatures showing the greatest degree differences were: 16° at 19.8 mile, 18° at Carbon Creek, 16° at Poncho's Kitchen, and 17° at 3 Springs Rapid. The variations in maximum temperature were probably due to convection currents and greater amounts of shading at certain beaches.

The lowest minimum temperature was 57° at Dino, and the highest minimum temperature was 90° at mile 19.8 (Table 5-2). The lowest and highest maximum temperatures were both recorded at National Canyon: 79° and 128° respectively.

The beach slope ranged from 3.5° at Carbon Creek to 25° at Poncho's Kitchen. Most slopes showed a gradual incline, with the exception of Grapevine and Poncho's Kitchen which had steep inclines. Some beaches exhibited varying terrain due to river washes, back eddies and alluvial deposits.

The average humidity was 51% at the river's edge and 49% at the talus slope. Five of the nine recordings along the river's edge had higher humidity readings than those of the talus slope. Two of the locations remained the same: Grapevine at 37% and Blacktail Canyon at 35%. Poncho's Kitchen and National Canyon both had an increase from 60% to 92% and 65% to 74% respectively.

Table 5-1

DAY	DATE	RIVER MILE	BEACH NAME	LOCATION	SLOPE (DEG.)
1	7/19/92	L 19.8	North Beach	EAST	8
2	7/20/92	R 50	Dino	SOUTH	10
3	7/21/92	R 64.6	Carbon Creek	WEST	3.5
4	7/22/92	L 81.3	Grapevine	SOUTH	6
5	7/23/92	R 120.2	Blacktail Canyon	NORTH	13
6	7/24/92	L 136.4	Poncho's Kitchen	SOUTH	25
7	7/25/92	L 166.6	National Canyon	SOUTH	9
8	7/26/92	L 166.6	National Canyon	SOUTH	9
9	7/27/92	R 216	3 Springs Rapid	WEST	11

Table 5-2

Location	Temp (F)	Sta #1	Sta #2	Sta #3	Sta #4	Sta #5	Sta #6	Sta #7	Sta #8	Sta #9
North Beach	Max	83	97	94	95	95	94			
	Min	72	68	85	88	90	88			
	Mean	77.5	82.5	89.5	91.5	92.5	91			
Dino	Max	97	115	98	100	98	100	100	101	
	Min	62	57	68	68	68	71	70	70	
	Mean	70.5	86	83	84	83	85.5	85	85.5	
Carbon Creek	Max	104	96	88	98	97	100	95	88	95
	Min	68	84	64	86	85	85	70	80	86
	Mean	86	90	76	92	91	92.5	82.5	84	90.5
Grapevine	Max	100	109	100	108					
	Min	80	73	86	88					
	Mean	90	91	93	98					
Blacktail	Max	104	109	100	107	104	101			
	Min	78	72	82	85	84	84			
	Mean	91	90.5	91	96	94	92.5			
Poncho's Kitchen	Max	80	93	84	86					
	Min	64	59	71	80					
	Mean	72	76	77.5	83					
National Day 1	Max	88	109	90	80		79	80	85	
	Min	68	72	59	71		70	76	74	
	Mean	78	90.5	74.5	75.5		74.5	78	79.5	
National Day 2	Max	108	125	120	128	120	120	116	120	
	Min	74	75	61	75	72	72	72	72	
	Mean	91	100	90.5	101.5	96	96	94	96	
3-Springs Rapid	Max	96	94	94						
	Min	59	71	76						
	Mean	77.5	82.5	85						

Table 5-3

Location	Slope (Deg)	Time P.M.	Sta #1(%)	Sta #2(%)	Sta #3(%)	Sta #4(%)	Sta #5(%)	Sta #6(%)	Sta #7(%)	Sta #8(%)	Sta #9(%)
North Beach	8	6:15	55	45	42	40		39		38	
Dino	10	7:25	37							19	
Carbon Creek	3.5	7:50	39							37	
Grapevine	6	6:30	37			37					
Blacktail Canyon	13	6:40	35					35			
Poncho's Kitchen	25	6:35	60			92					
National Canyon	9	7:10	65								74
National Canyon	9	9:15	77								57
3 Springs Rapid	11	6:45	56		55						

Table 5-4

Location	Mile	Time P.M./Temp (F)	Time A.M./Temp (F)
North Beach	19.8	6:45/50	7:10/50
Dino	50	7:25/53.6	6:55/53.6
Carbon Creek	64.6	7:05/53.6	6:00/53.6
Grapevine	81.3	6:30/55.4	7:00/55.4
Blacktail Canyon	120.2	6:40/57.2	7:00/57.2
Poncho's Kitchen	136.4	6:35/57.2	7:15/57.2
National Canyon	166.6	7:10/59	9:15/59
National Canyon	166.6	7:20/59	7:30/59
3 Springs Rapid	216	6:45/64.4	7:00/64.4

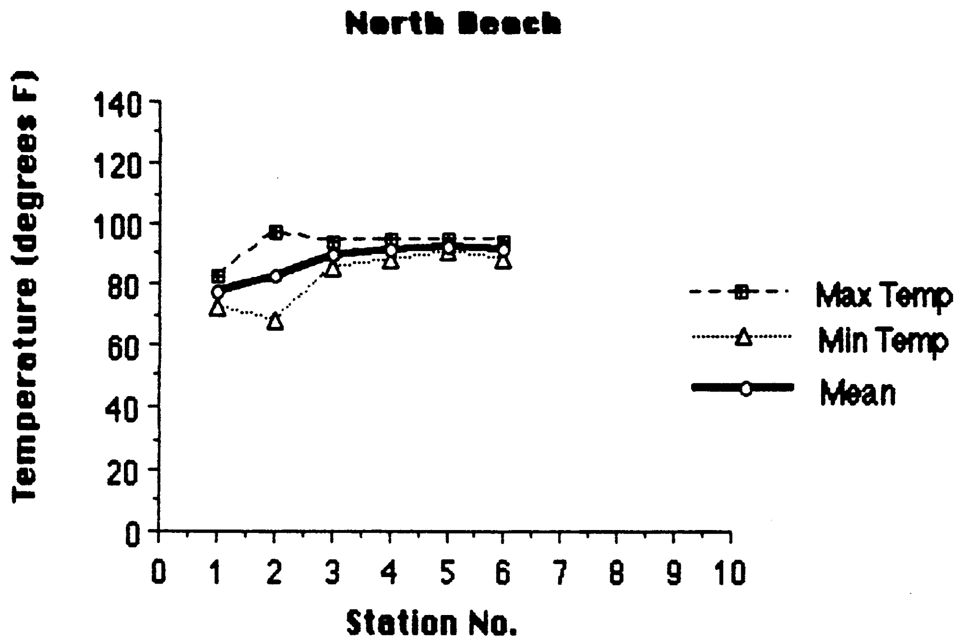
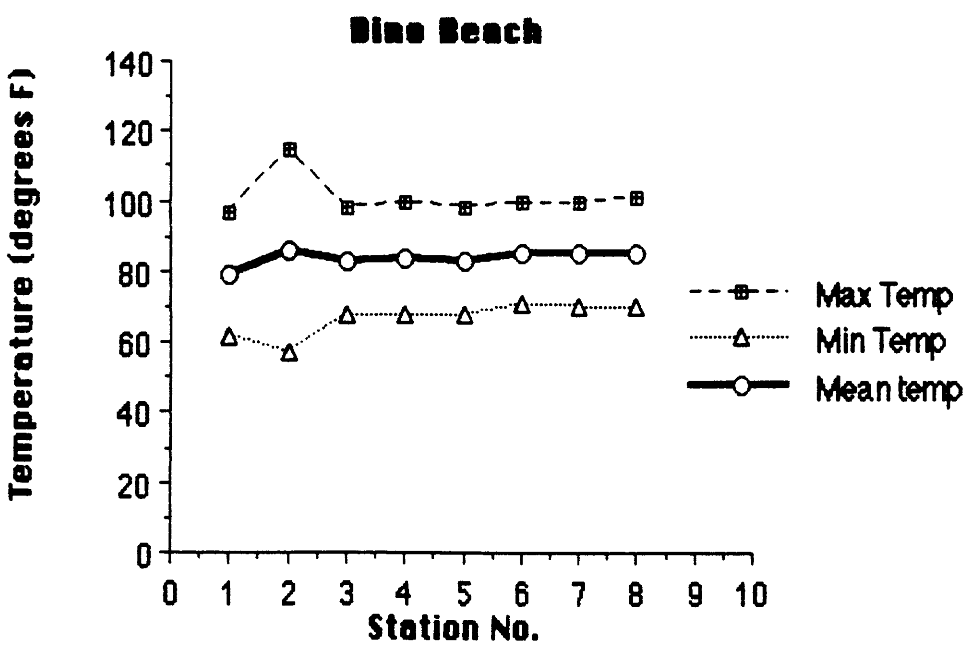


Figure 5-1



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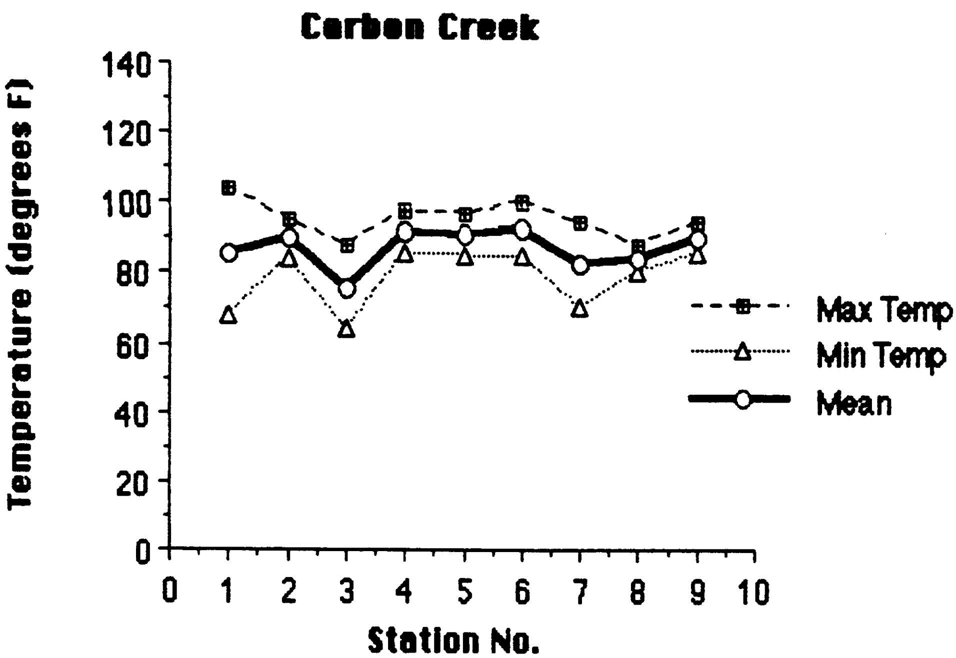

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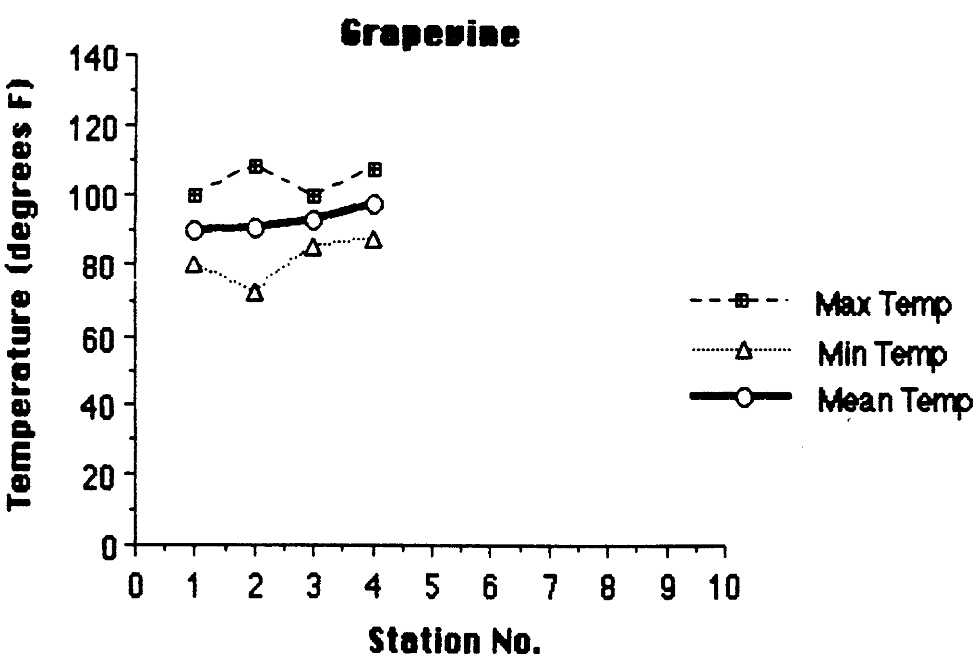

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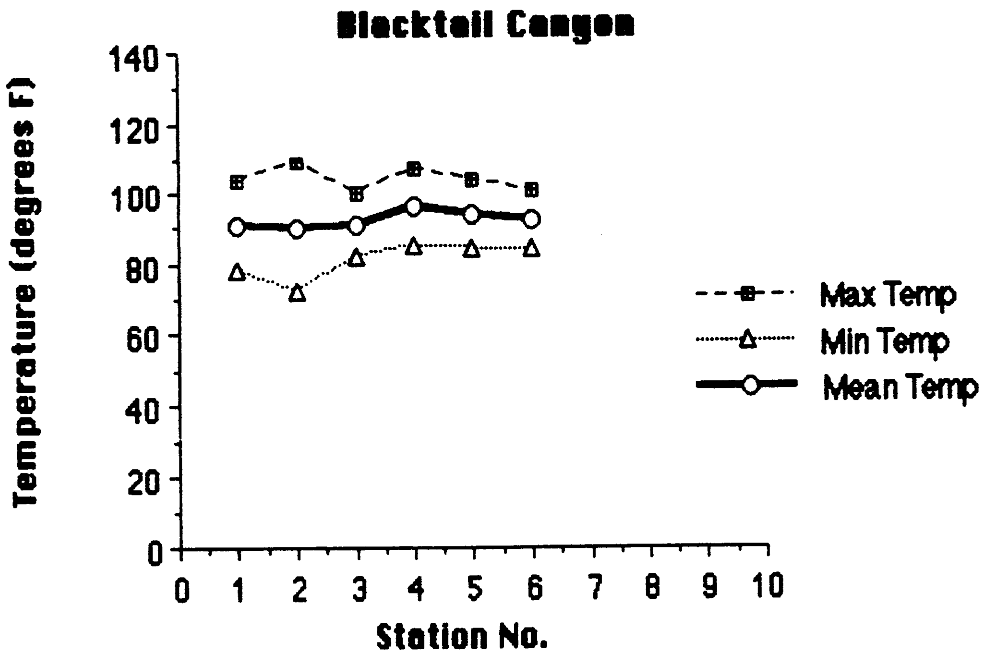

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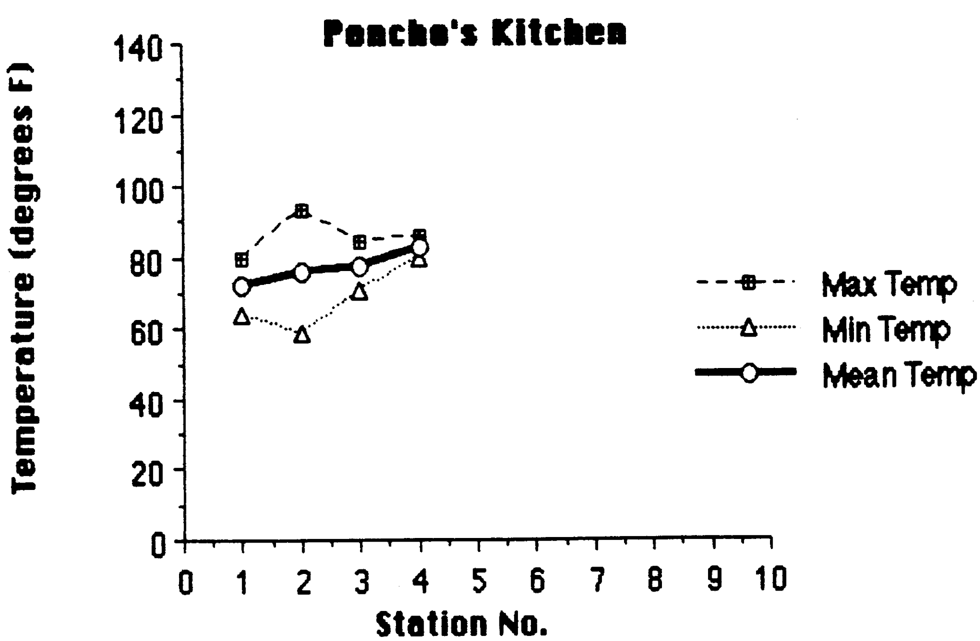

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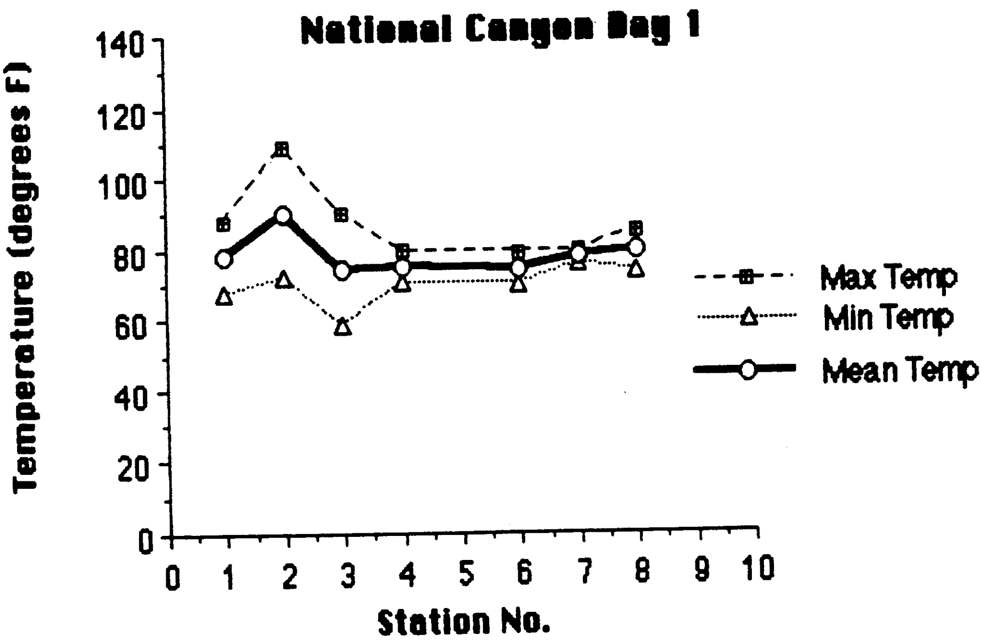


Figure 5-7

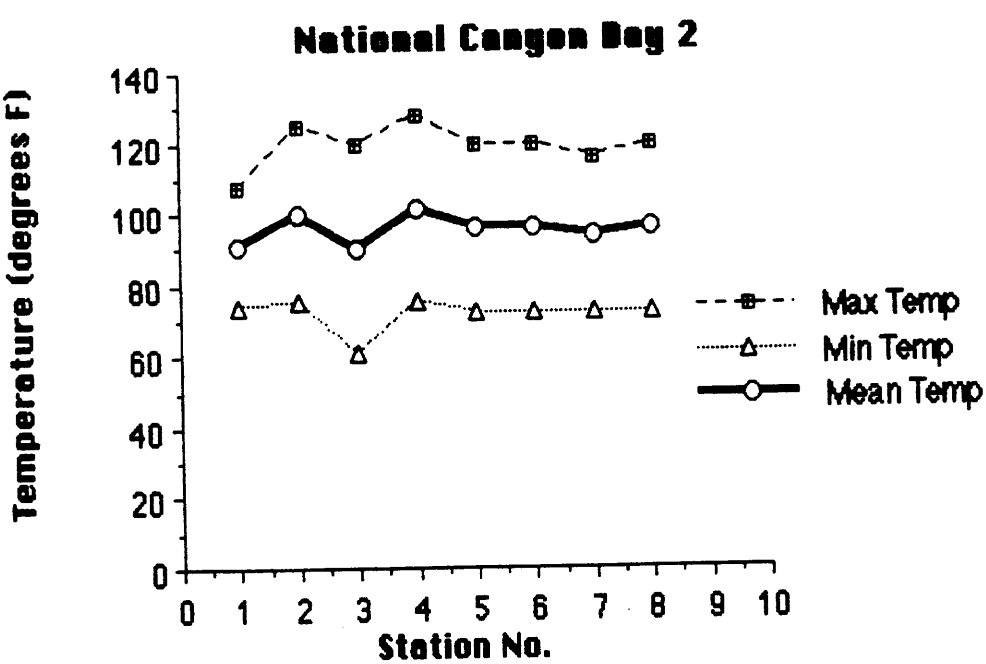
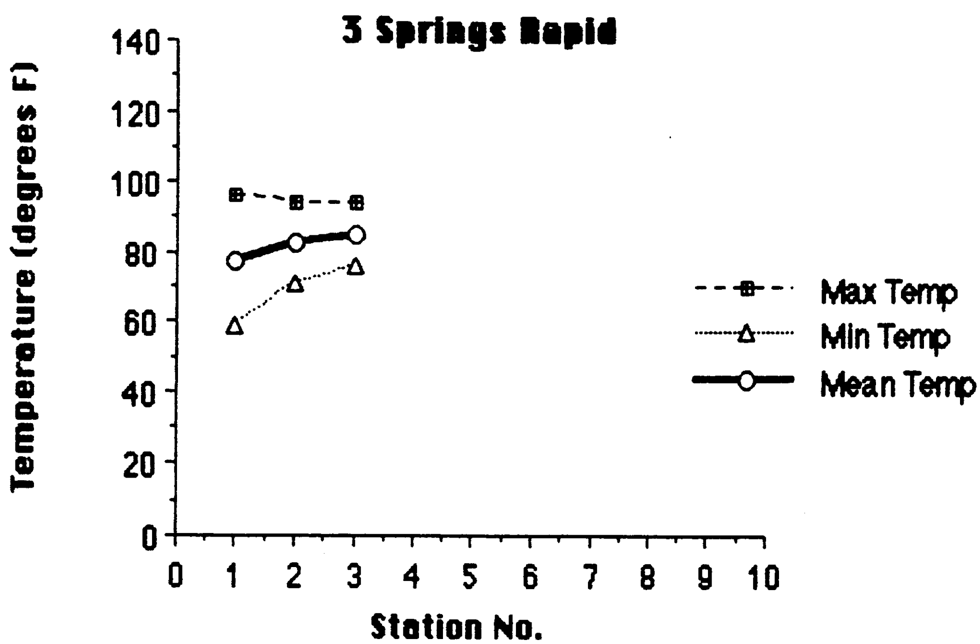


Figure 5-8



3 Springs Rapid
Temperature (degrees F)
140
120
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10
Station No.
Max Temp
Min Temp
Mean Temp

Figure 5-9

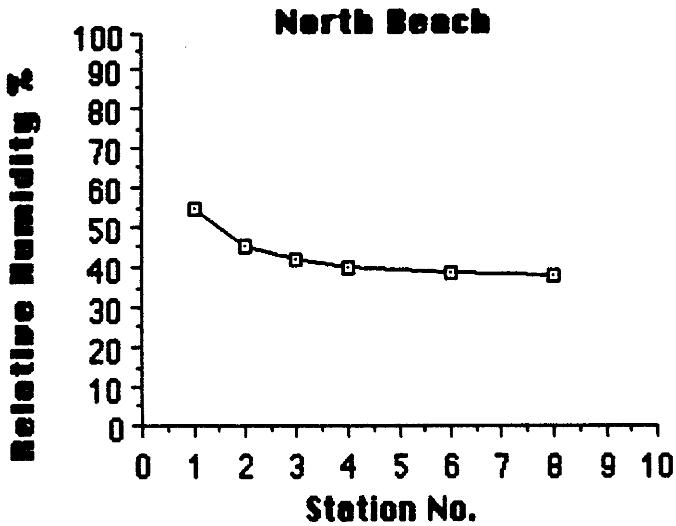
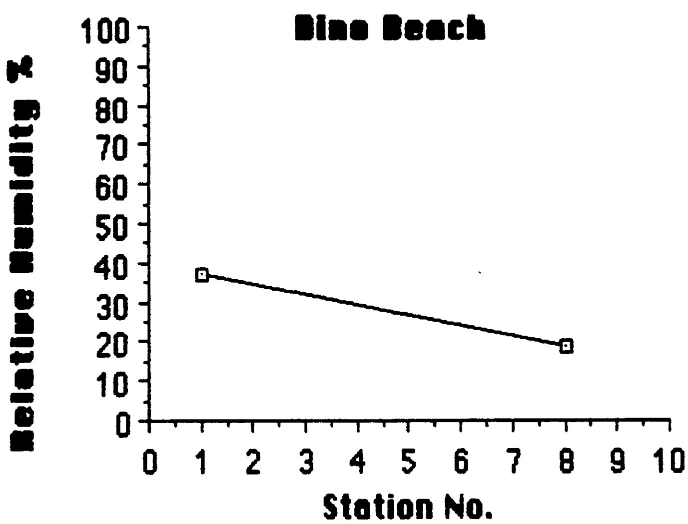


Figure 5-10



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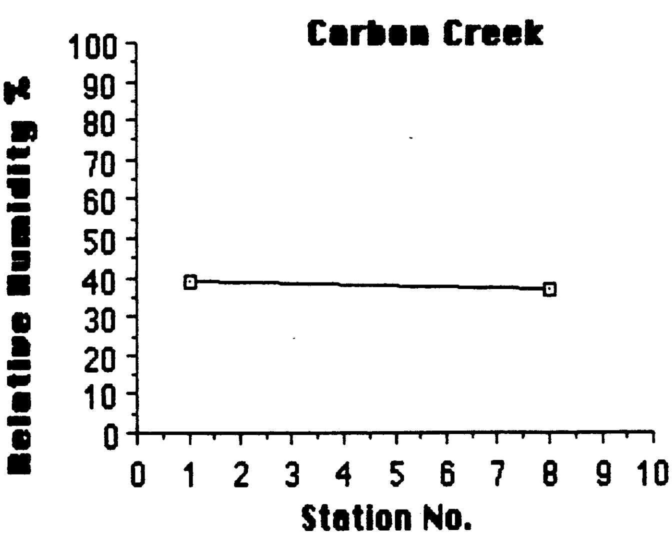

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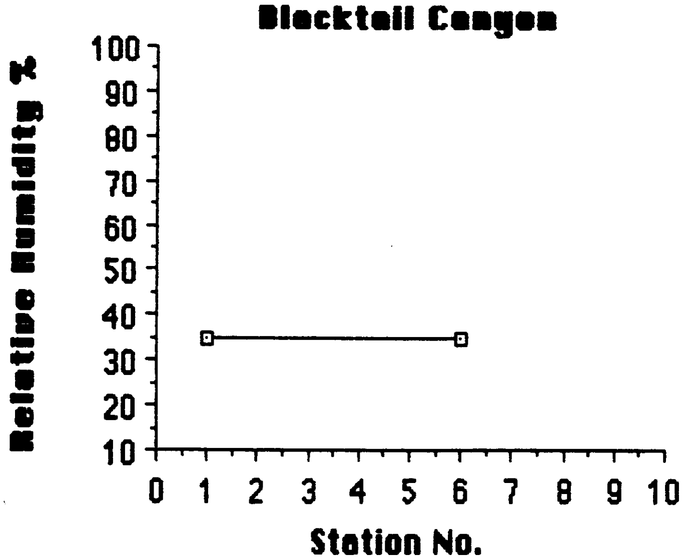

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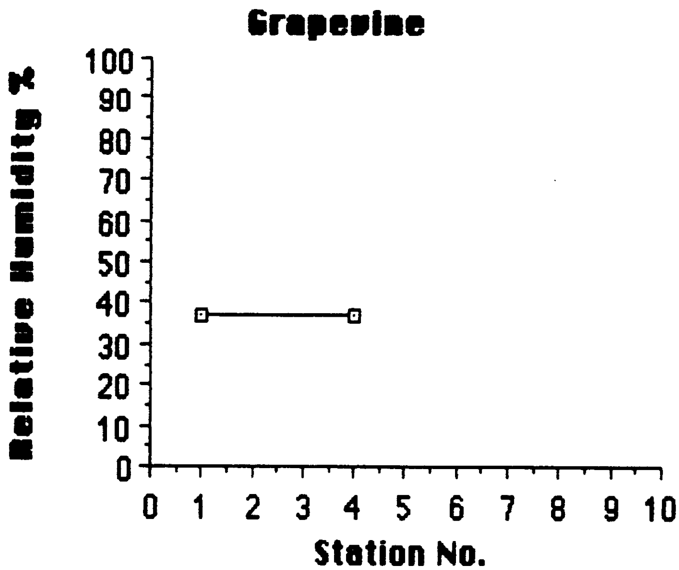
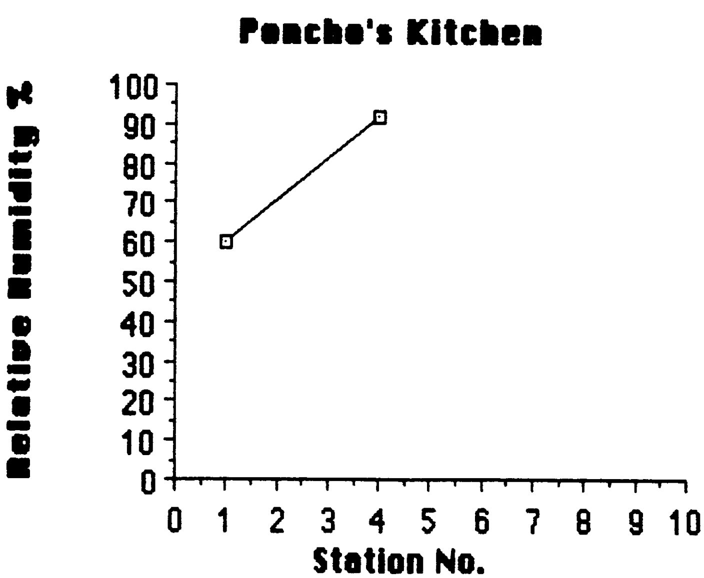


Figure 5-14



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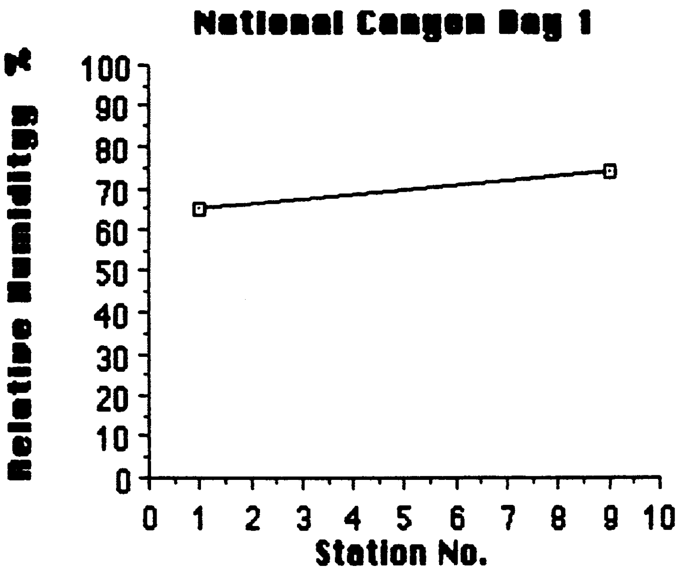

Figure 5-16

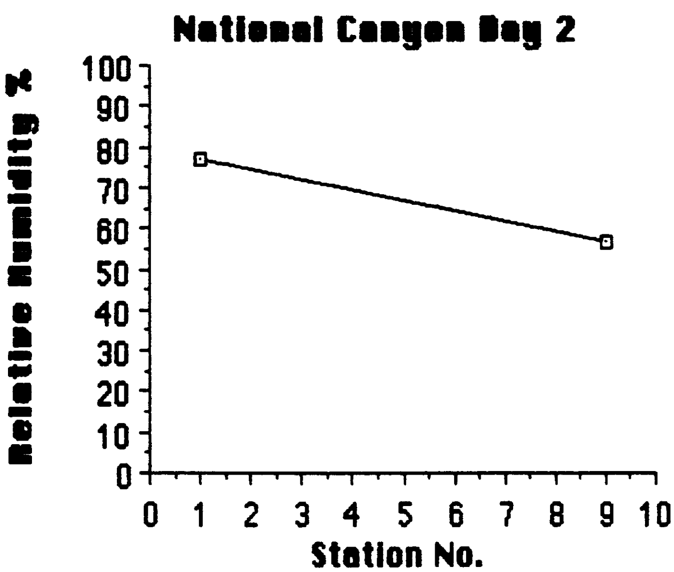

Figure 5-17

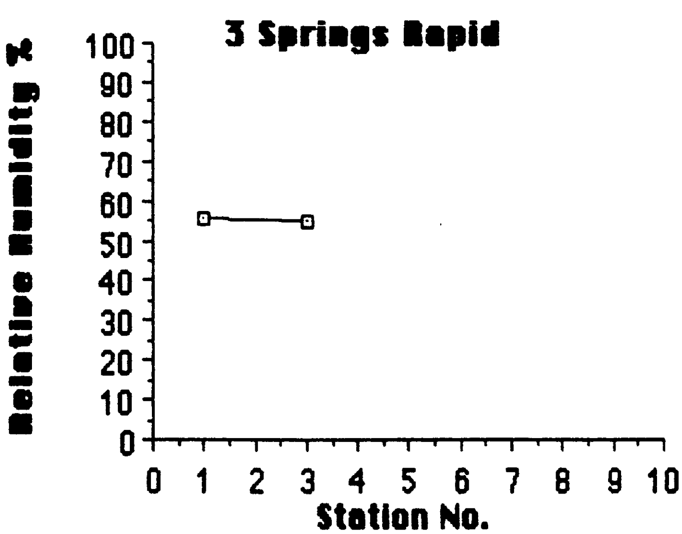

Figure 5-18

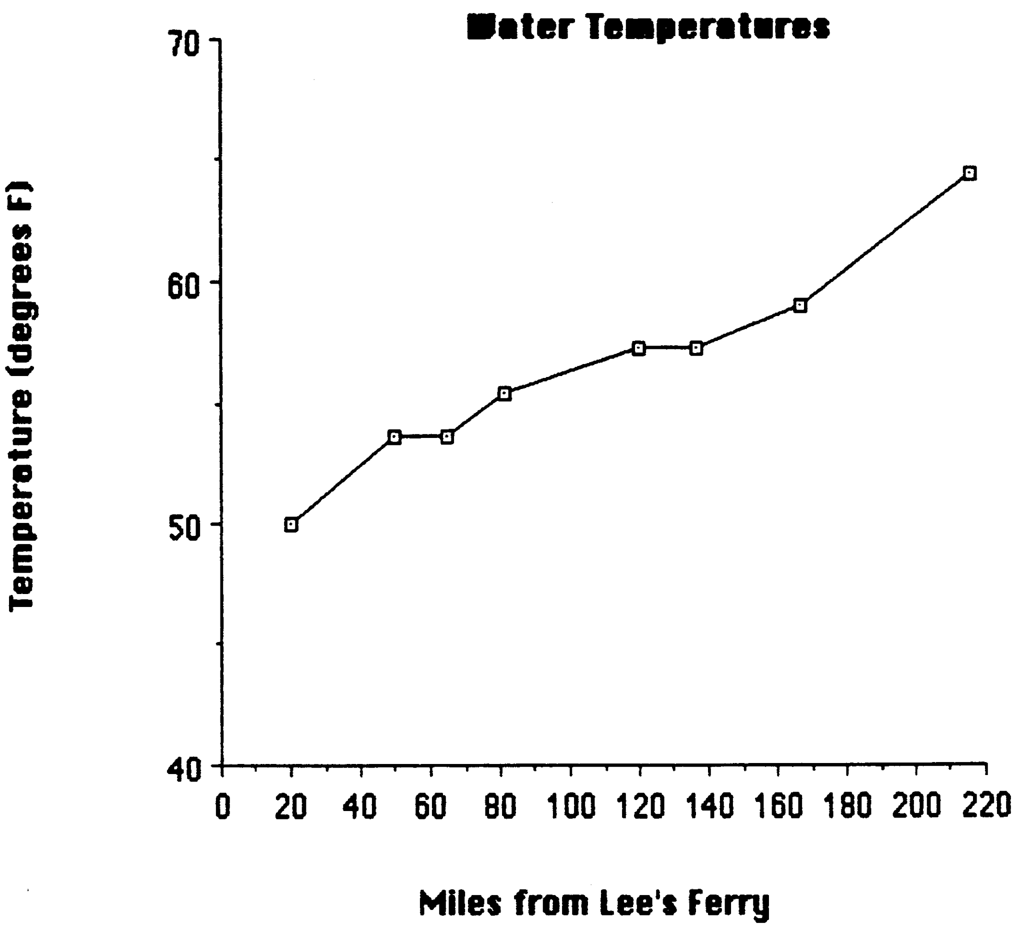
Water Temperatures
Temperature (degrees F)
70
60
50
40
0
20
40
60
80
100
120
140
160
180
200
220
Miles from Lee's Ferry

Figure 5-19

The water temperature increased gradually from 50° at North Canyon to 64.4° at 3 Springs Rapid. Morning and evening temperatures at each location were the same.

The moisture in the soil was determined by using a commercial plant moisture detector. The reading at the river's edge was a maximum of 10, and at the 10 meter mark there was no moisture observed. This was also true for all other stations.

Cloud cover above the canyon was generally scattered cumulus clouds. Friday (7/24/92) afternoon was overcast with showers into the evening. Saturday afternoon was overcast also, but the weather was basically clear for the remainder of the trip..

Wind speed was generally from 10-20 m.p.h. and blowing down the canyon. The windiest locations were at Carbon Creek and Grapevine.

CONCLUSIONS

The results of the study verify the hypothesis that the temperature does increase as a function of the distance from the river's edge to the talus slope on the beaches within the Grand Canyon Corridor. There was as much as an 18° difference for the minimum temperature and a 12° difference for the maximum temperature. Deviations were probably due to other physical factors such as the type of ground cover (silt, sand, rock), color of the ground surface, plant density, wind direction, and the amount of shade present.

There was no apparent correlation between elevation and temperatures due to the variation in weather patterns during the ten day study. A better method would have been to compare temperatures along the river for the same day, but this was not possible.

There was also no apparent correlation between the degree of slope and the temperature. A more in depth study, or one that involved the same beach with several different profiles (to minimize other variables), would need to be conducted in order to investigate this question further.

Another observation was that after 30 meters, there seemed to be a leveling off of temperatures, indicating that after that point, the cold air generated by the river had little affect on the temperatures.

There was less correlation between the relative humidity and proximity to the river. Five of the nine recordings had a higher amount of moisture near the river than at the talus slope, as can be expected. However, other factors such as changing weather patterns (an approaching storm), probably had a greater affect on relative humidity.

The increase in water temperature from Lee's Ferry to Lake Mead was expected, and was largely due to the distance traveled and the heat of the sun.

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CHAPTER 6

THE RELATIONSHIP BETWEEN SOIL TEXTURE AND PLANT SURVIVABILITY OF *Pluchea servicea*, *Diccoria brandegei* & *Salix exgua*

TIM DAUWALDER AND JEAN MAYER

INTRODUCTION

Soil texture can determine plant water availability, germination success, growth rate and reproductive success (Stevens, 1989). This study focuses on the relationship between soil texture and the success of Arrowweed (*Pluchea servicea)*, *Diccoria brandegei* and Coyote Willow (*Salix exgua*) along the Grand Canyon Colorado River corridor. Since the Glen Canyon Dam, sediments that normally flowed through the Colorado River corridor have changed, perhaps in a way that may affect the distribution and success of plants along the river. Also, flow regimes and ramping rates of the dam significantly affect beach deposition and stability. Due to the multifaceted effects of soil texture on plant success, it is difficult to isolate one variable that is more responsible for increased species competitive ability.

Species that are better suited for survival in sediments containing less silt and clay may be more competitive in the new high water zone.

The Dam has been responsible for significantly decreasing the amount of silt and clay deposition. The rate of successional change among these three species has been affected by the flow fluctuations and sediment changes caused by Glen Canyon Dam (Carothers, 1991). The three test species indicate competitive advantages concerning reproductive success, drought tolerance, and seed germination in the present soil texture.

METHODS

At designated beach sites along the Colorado River of the Grand Canyon corridor, we collected soil samples from the root crown region of *Pluchea*, *Diccoria* and *Salix* seedlings. To determine whether or not the sample was a true seedling or part of an advantageous root system, we would first look for isolated seedlings that were away from an obvious parent plant. Then, we would scrape a small amount of top soil away in an attempt to uncover any advantageous roots. Once a seedling was determined to be of the appropriate species and was not asexually propagated, we then would extract a soil sample of approximately 40 grams from the root crown region.

Soil samples were extracted using a garden spade and two six-inch putty knives. Before digging the hole, one putty knife was inserted into the soil adjacent to the root stem to prevent soil from falling around the root when exposed. With that knife in place, we would gently scrape the soil away from the originally placed knife. The remaining putty knife and spade were placed together so that the concave surface of the spade was in contact with the flat surface of the putty knife. This formed a space between the two surfaces. With knife and spade together, we would insert them into the soil horizon at the root crown. The knife and spade were extracted and a core soil sample filled the space .

Each soil sample was massed before being placed into U.S. Standard Sieves. The sieves consisted of nine graduated screens and a collecting pan at the bottom. The graduations ranged from U.S. Standard Sieve #18 (Phi 0.0) to sieve #230 (Phi 4.0) (Table 3). The samples were shaken for a time period of 15 minutes to physically sift the materials. After sifting, each graduated sieve was separated and the contents were massed.

Phi means were calculated for each Phi size for all samples of a given species. An ANOVA analysis was conducted to determine if Phi means of the three test species were significantly different.

RESULTS

Soil samples taken from the root crown of *Salix exigua* *Pluchea servicea* and *Dicorria brandegei* in the new high water zone of the Grand Canyon corridor showed no significant differences in soil texture (Table 1). The mean Phi sizes for *Salix* , *Pluchea* and *Dicorria* are 2.50, 2.39 and

2.27 respectively (Table 2). The majority of samples from all treatments indicated a fine to medium sand grain texture ranging from Phi 2.0-3.0 (Figures 1, 2, 3; Table 3). The Phi size of 2.5 represented the most common grain size for all tested species (Figures 1, 2, 3). *Salix* soil samples showed some inconsistency in the 0.0 Phi range when compared to *Pluchea* and *Diccoria* (Figure 3). This noted difference is primarily due to one sample obtained at Nautiloid Canyon which contained pebbles totalling nearly 25% of the total mass. The remaining percentage of the mentioned soil sample contained fine to medium grained sand which corresponded to the other samples of the treatment (Figure 3).

DISCUSSION

Soil samples taken from the root crown of *Pluchea*, *Diccoria* and *Salix* showed no significant difference in average Phi sizes (Tables 1, 2). Since Glen Canyon Dam, sediment deposition and beach stability has been altered. Consequently, the riparian plant habitat along the Colorado River of the Grand Canyon has been subjected to decreased silt and clay deposition (Carothers, 1991). The assumption that the sand texture may affect species success is the underlying principle of this study. Apparently, soil texture is not significantly different among the tested species, which would imply that soil texture has little effect on the growth and success of our tested species. However, the rate of plant

TABLE 1: ANOVA SUMMARY

	df	SS	MS	F
Treatments	2	.00221	.0011	.0005999
Error	27	49.559	1.8335	
TOTAL	29	49.561		F< 3.35

TABLE 2 : MEAN PHI SIZE

Treatments	Phi size
Pluchea servicea	2.5
Dicorria brandegei	2.39
Salix exgua	2.27

TABLE 3: GRAIN SIZE COMPARISONS

US STANDARD SIEVE SIZES	MILLIMETERS	PHI	DESCRIPTION
18	1.00	0.0	very coarse sand
25	.71	.5	coarse sand
35	.50	1.0	coarse sand
45	.35	1.5	medium sand
60	.25	2.0	medium sand
80	.177	2.5	fine sand
120	.125	3.0	fine sand
170	.088	3.5	very fine sand
230	.0625	4.0	very fine sand
325	.044	4.5	coarse silt

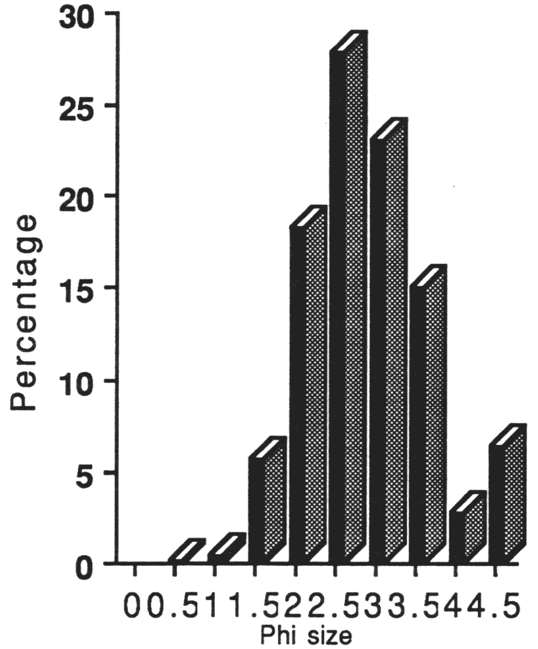

FIG. 1 AVERAGE PHI % Pluchea servicea SOIL

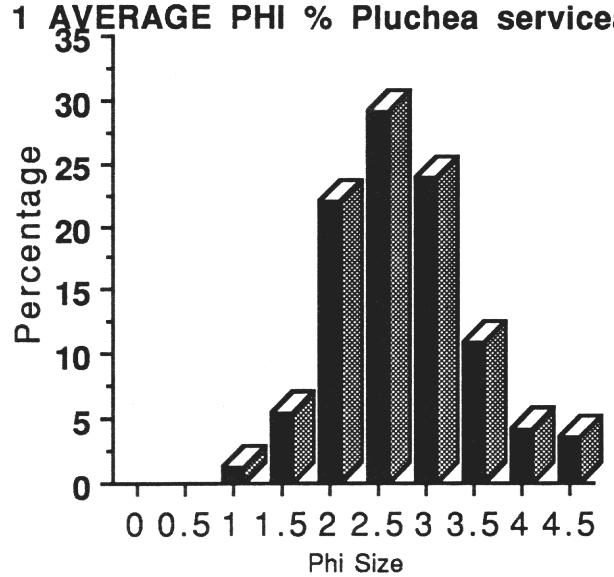

FIG.2 AVERAGE PHI % Dicorria brandegei SOIL

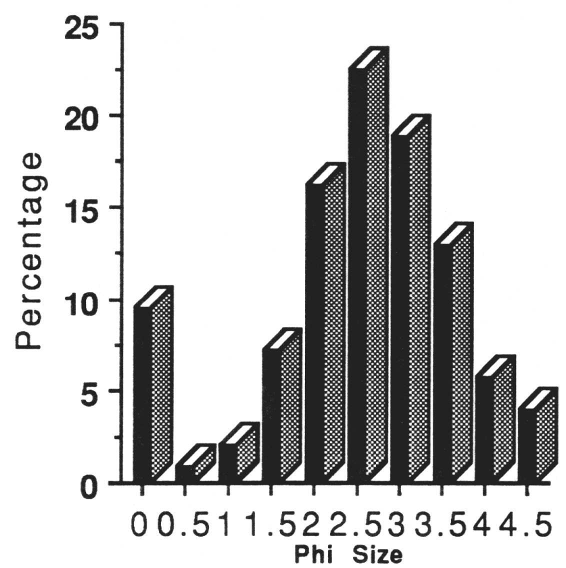

FIG.3 AVERAGE PHI % Salix exgua SOIL

succession and long term reproductive success could be partially dependent on soil texture.

The ability of soil to retain water is dependent upon the amount of silt and clay present. Our soil samples indicated an average of 8.8% Phi sizes greater than 4.0. In Stevens' (1989), Mechanisms of Riparian Plant Community Organization and Succession in the Grand Canyon, Arizona, it was determined that "silt rich substrates were relatively rare in the Colorado Corridor, comprising only 9.5% of the terrace below the 1,130 m^3/sec stage". Due to the low percentage of silt rich substrate, the water holding capacity of the tested soil is low. *Diccoria* treatments showed the least percentage of Phi size less that 4.0 equalling 7.7% of the total soil. The *Pluchea* and *Salix* soils showed 9.1% and 9.6% Phi size less that 4.0, respectively. The percentage of silt and clays present in *Diccoria* corresponds to the sandy dunes they colonize. Contrarily, *Pluchea* and *Salix* grow primarily in sandy soils in or adjacent to the high water mark, which relates to the greater percentage of silt rich substrates. *Diccoria* was apparently more zerophytic and better adapted to the dry sandy soils of the dune areas. There were many new seedlings and mature *Diccoria* plants on the dunes, indicating a tolerance of higher temperatures and less available water.

The decrease in silt-rich soil when comparing Stevens' findings of

9.5% silt rich substrate to our 8.8% is intriguing. The number and location of our samples could explain the difference. However, decrease silt deposition could be related to beach scouring and dam ramping rates. The sediment-free water exiting the dam has "enormous potential to erode, little ability to deposit. As a result, all the new sediment needed to replenish eroded deposits in the river corridor must come from tributaries within the canyon" (Carothers, 1991). Today, tributary input of sediments is responsible for the river sediment content and beach deposition. The silt holding capacity of the river water is increased due to the sediments being trapped by the dam, creating a greater potential for beach erosion. The decreased percentage of silts in our study relative to Stevens' conclusions may be a response to increased beach scouring and decreased deposition of sediment. The similarities of soil texture between our tested species implies the ability of these species to survive in sandy soil. However, the decrease in fine sediments for all species involved can potentially select against any one, or all, of these species.

The ability of *Salix* and *Pluchea* to colonize sandy soils is responsible for their success along the Colorado River and their apparent competitive advantage over the introduced *Tamarix*. *Tamarix* has a deep root system and, consequently, is dependent on its very large seed production for reproductive success. Contrarily, *Pluchea* and *Salix* both demonstrate clonal reproduction, using shallow advantageous roots. The ability of *Salix* and *Pluchea* to propagate quickly and without major seed production may account for the apparent dominance of these species over the *Tamarix* during the past few years. The effects of present soil texture on the reproductive success of these species is unclear. Perhaps, the lack of *Tamarix* seedlings could be a response to coarser soils which may benefit the production of advantageous roots (Carothers, 1991).

In determining if soil texture had any affect on the success of our test species, we averaged the Phi size from all beaches for each species. We did not analyze and compare the soil texture of specific beaches along the river. Therefore, predicting the successional rate and competitive abilities determined by soil texture for a specific species is difficult. We documented a great variety of plant density among the tested species as we progressed down the river. This variety could be attributed to varying soil textures not represented by the average soil Phi size determined for each species. Lojko (1984) noted that the heavier grained sediment is deposited further upstream while the lighter grained sediment remains in suspension, thus floating further downstream to be deposited.

An explanation for beach vegetation diversity could be increased silt deposition as progression is made down the river.

We observed a *Salix* dominated riparian zone with primarily older growth *Tamarix* prior to the confluence of the Little Colorado River. Large, well-established stands of *Pluchea* were noticed after Nankoweap and continued throughout the corridor. In the majority of sampling locations when *Salix* dominated a beach, less *Pluchea* was noticed and vice versa. This strongly suggests a competitive relationship between *Pluchea* and *Salix*. Both species occupy similar locations relative to the river and have similar reproductive characteristics. Our results and observations suggest that this dominance is not due to soil texture alone. Temperature, elevation and water availability are other variables that must be considered when contemplating the *Salix/Pluchea* relationship. Proceeding down the river, the elevation drops and temperature rises. This causes the sand to dry out before the seeds are able to germinate. This may partly be the reason why more *Salix* are observed above Phantom Ranch (Carothers, 1991). If any generalizations were to be made, it appears that on open beaches with little or no debris and direct sunlight, *Salix* had no problem colonizing (Brian,1982) and is therefore gradually invading beaches of the Colorado River corridor. In areas where *Tamarix* seemingly dominates a beach, at closer inspection, small *Salix* seedlings are invading the region.

CONCLUSION

The average mean Phi sizes of the soil samples taken from *Pluchea*, *Diccoria* and *Salix* showed no significant difference. Nevertheless, silt rich sediments seem to be diminishing when compared to the noted percentage of silt rich substrate in previous studies. The effects of soil texture in the Colorado River corridor on our tested species is inconclusive. The many variables controlling the success of plant species in the riparian zone, including dam discharge, water availability, grain size, elevation, temperature, and reproductive strategies are coupled with soil texture. It is still feasible that changing sediment deposition can have a significant affect on the plants of the riparian zone of the Colorado River corridor. But, in our study, sediment texture had no apparent adverse affect when considering *Pluchea*, *Diccoria* and *Salix* survivability. However, if fine sediments continue to decrease beyond the Glen Canyon Dam, soil water holding capacity and the riparian community will undoubtedly be affected.

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CHAPTER 7

RODENT POPULATIONS AND DISTRIBUTION WITHIN THE COLORADO RIVER CORRIDOR

Bill Blume, Scott Greenhalgh, and Dan Zanone

INTRODUCTION

The completion of Glen Canyon Dam in 1963 has had a profound effect on the riparian environment of the Colorado River Corridor. This is most evident in the creation of a new riparian zone described by Carothers et al. in 1976, and shown in Figure 7-1. This study is a continuation of a longitudinal investigation of the distribution and abundance of terrestrial rodents within zone 2, marking the pre-dam high water flood zone, and zone 4, marking the new high water flood zone. Beginning in October of 1991, Glen Canyon Dam began interim flow water releases which limited the maximum flow to 20,000 cfs and the minimum flow to 5,000 cfs. Our research was conducted in July of 1992, and we hypothesized that this flow regime over the past ten months would have created a more stable streamside environment and a subsequent increase in the rodent population of zone 4. Our study will not only examine the Grand Canyon river corridor rodent population as a whole, but will also focus on one beach, National Canyon, that has been a trapping site for all previous rodent research teams of the Colorado River Investigations.

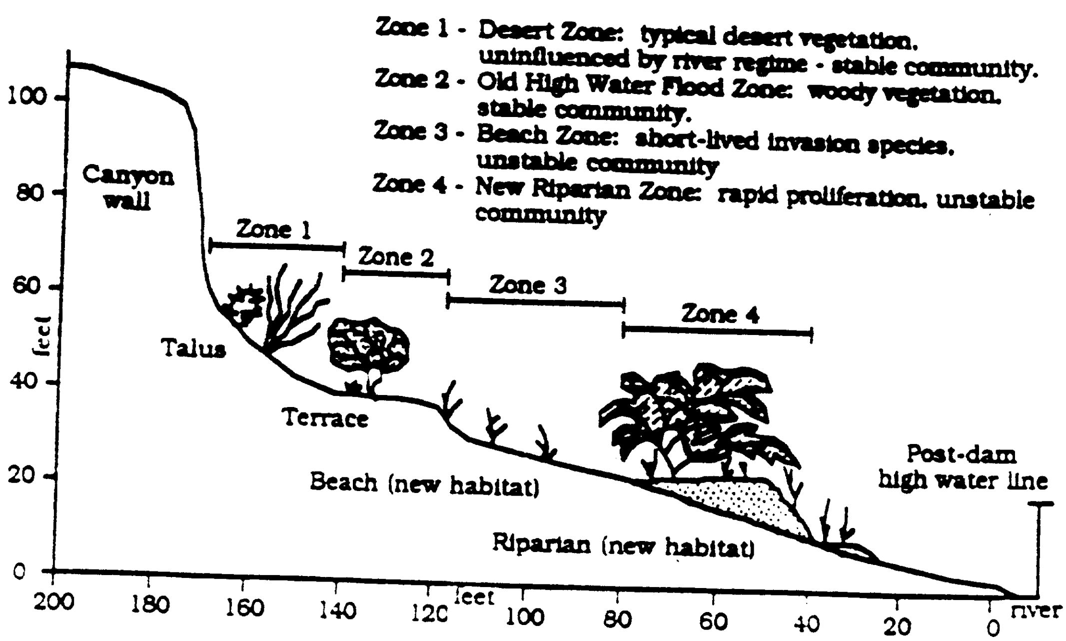

Figure 7-1. Diagrammatic cross-section of vegetation zones in the Inner Gorge of the Colorado River in Grand Canyon after construction of Glen Canyon Dam (adapted from Carothers, et. al., 1979).

METHODS

The following data was compiled over the course of an eleven day river trip July 19-29, 1992 at various campsites along the Colorado River Corridor (see Table 7-1.). Each evening the researchers baited and distributed approximately sixty Sherman live traps with thirty being placed in zone 4 and the other thirty in zone 2. The bait used was the same as the previous year, with each trap containing a few oatmeal flakes and a raisin. The following morning we determined the genus, gender, and weight of each rodent captured and released them unharmed. Previous reports have expressed a concern over inconsistencies in identification of rodents by species (Garavito and Mowery 1991, and Kendall et al., 1988). It was decided that to avoid any misclassification we would identify the rodents by genus (*Peromyscus, Perognathus*, and *Neotoma*). In comparing our data to previous years, we have converted their data to reflect our emphasis on genus. In addition, some previous researchers chose to sample rodent populations in zones 1, 2, 3, and 4 (Rotstein et al., 1987 and Kendall et al.,1988). For the purpose of comparison with our data, we have combined zones 1 and 2 in these studies as zone 2, and zones 3 and 4 as zone 4.

RESULTS

Tables 7-1 and 7-2 summarize the data from the captures at each beach in this study. The overall capture success rate for 1992 was 16%. Figure 7-2 compares the overall capture totals of the three genera on this expedition: 79.3% *Peromyscus*, 17.1% *Neotoma*, and 3.6% *Perognathus*. Figure 7-3 shows the capture totals at each beach by genus. Figure 7-4 compares capture totals of males and females, 41.3% and 58.7% respectively. Figure 7-5 compares the capture totals of zones 2 and 4, 56% and 44% respectively.

TABLE 7-1

Date	Beach	*Peromyscus*		*Perognathus*		*Neotoma*	
		Zone 2	Zone 4	Zone 2	Zone 4	Zone 2	Zone 4
7/20/92	Mile 19.3 (R)	0	2	0	0	0	0
7/21/92	Little Dino (R)	6	4	0	0	2	1
7/22/92	Carbon Creek (R)	6	7	0	0	3	0
7/23/92	Grapevine (L)	1	4	0	0	0	0
7/24/92	Blacktail (R)	2	0	0	0	2	0
7/25/92	Pancho's Kitchen (L)	11	7	0	0	2	0
7/26/92	National Canyon(L)	8	7	2	1	1	3
7/28/92	Mile 216 (R)	0	0	0	0	0	0
TOTALS		**34**	**31**	**2**	**1**	**10**	**4**

TABLE 7-2

Date	Beach	ZONE 2		ZONE 4	
		Traps Set	Rodents Caught	Traps Set	Rodents Caught
7/20/92	Mile 19.3 (R)	31	2	30	0
7/21/92	Little Dino (R)	36	6	36	7
7/22/92	Carbon Creek (R)	35	9	36	7
7/23/92	Grapevine (L)	30	1	30	4
7/24/92	Blacktail (R)	30	4	30	0
7/25/92	Pancho's Kitchen (L)	33	13	30	7
7/26/92	National Canyon (L)	33	11	29	11
7/28/92	Mile 216 (R)	30	0	33	0
TOTALS		**228**	**46**	**221**	**35**

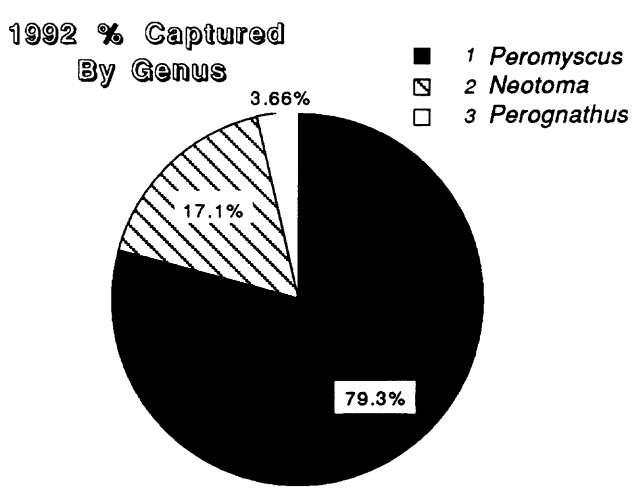

FIGURE 7-2

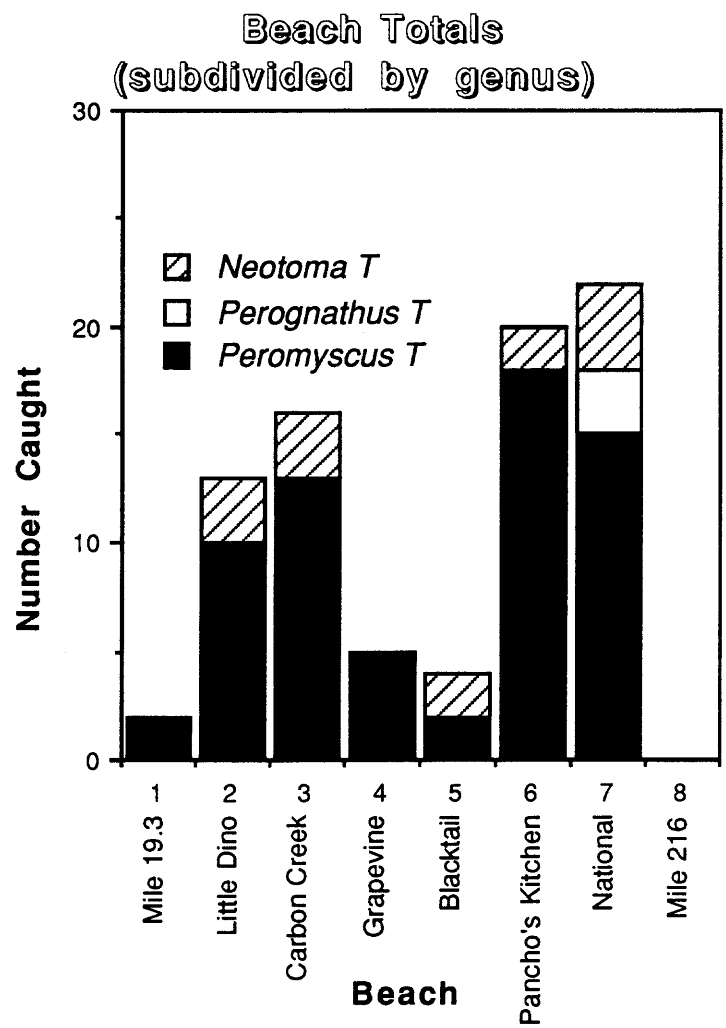

FIGURE 7-3

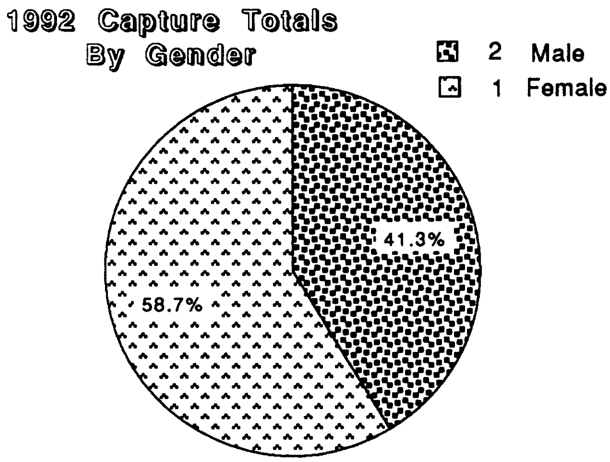

FIGURE 7-4

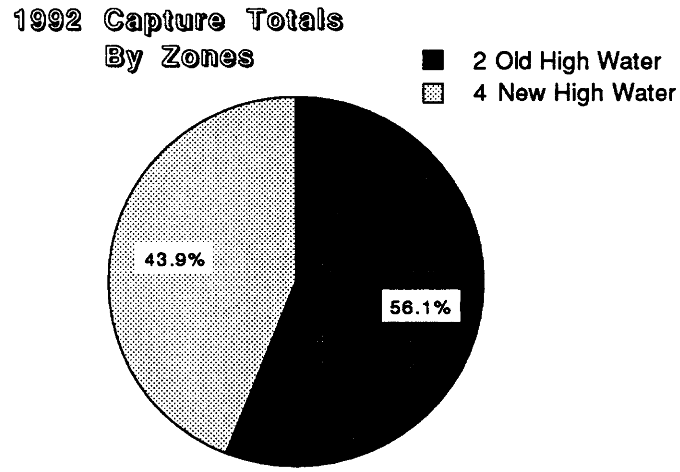

FIGURE 7-5

Figure 7-6 compares the capture rates for zone 2 and zone 4 throughout the longitudinal study. It is apparent that zone 4 has lost ground over the last three years, though it is slightly higher than in 1983. Figure 7-7 shows the capture rates for the zones on National Beach, the only beach consistently studied. The trend here seems to be an increase in the percentage of rodents captured in zone 4.

Figure 7-8 shows the adjusted capture totals for the three genera included in the longitudinal study.

Figure 7-9 compares the longitudinal capture rates of the *Peromyscus* and *Perognathus* genera of mice. This data indicates that there is an inverse relationship in the capture rate of *Peromyscus* and *Perognathus*.

RODENT CAPTURES IN ZONES 2 & 4 OF THE COLORADO RIVER CORRIDOR (longitudinal study)

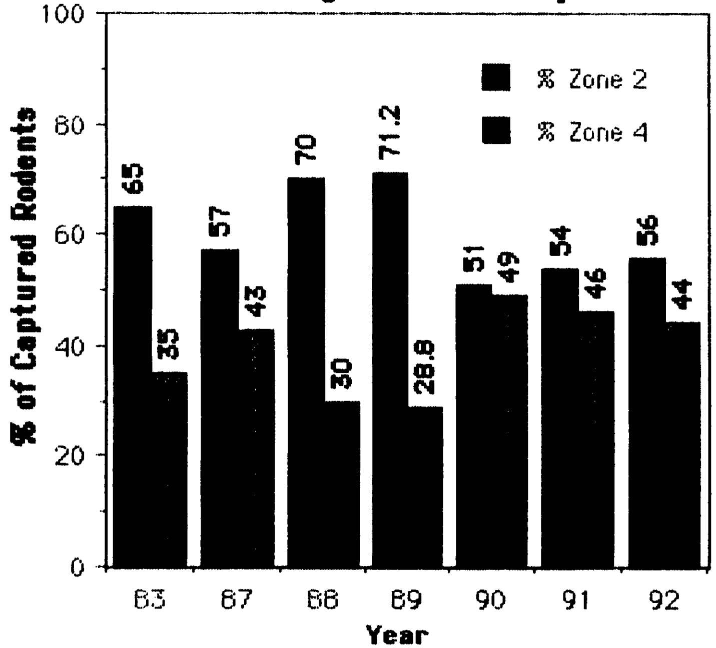

Figure 7-6

ZONE COMPARISON OF NATIONAL CANYON BEACH (longitudinal study)

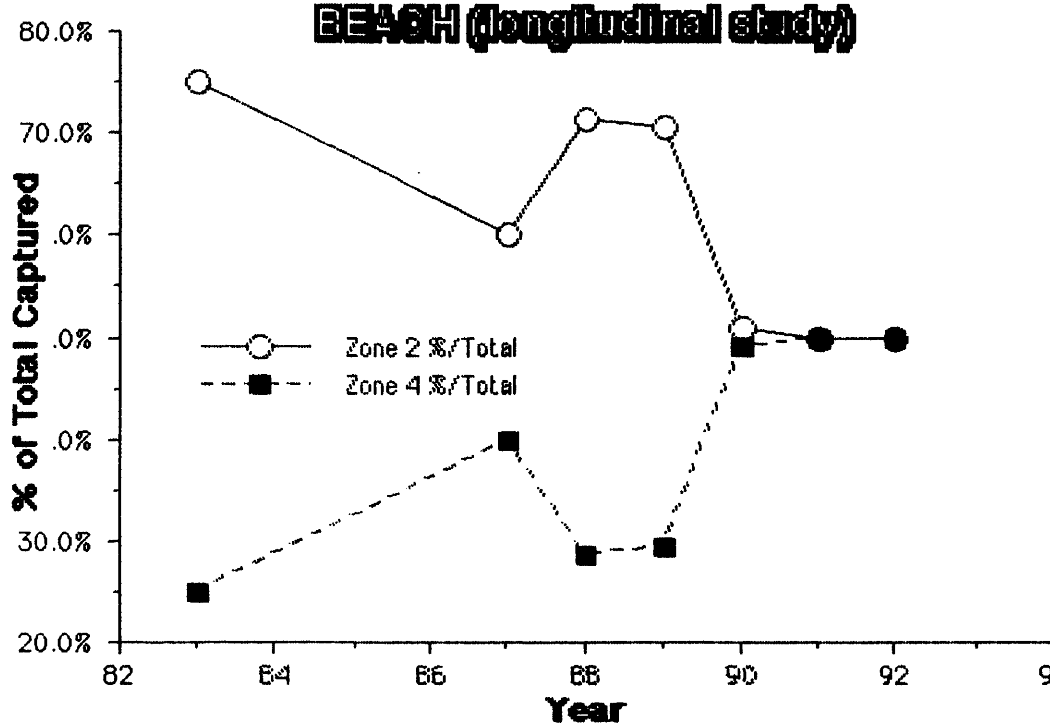

FIGURE 7-7

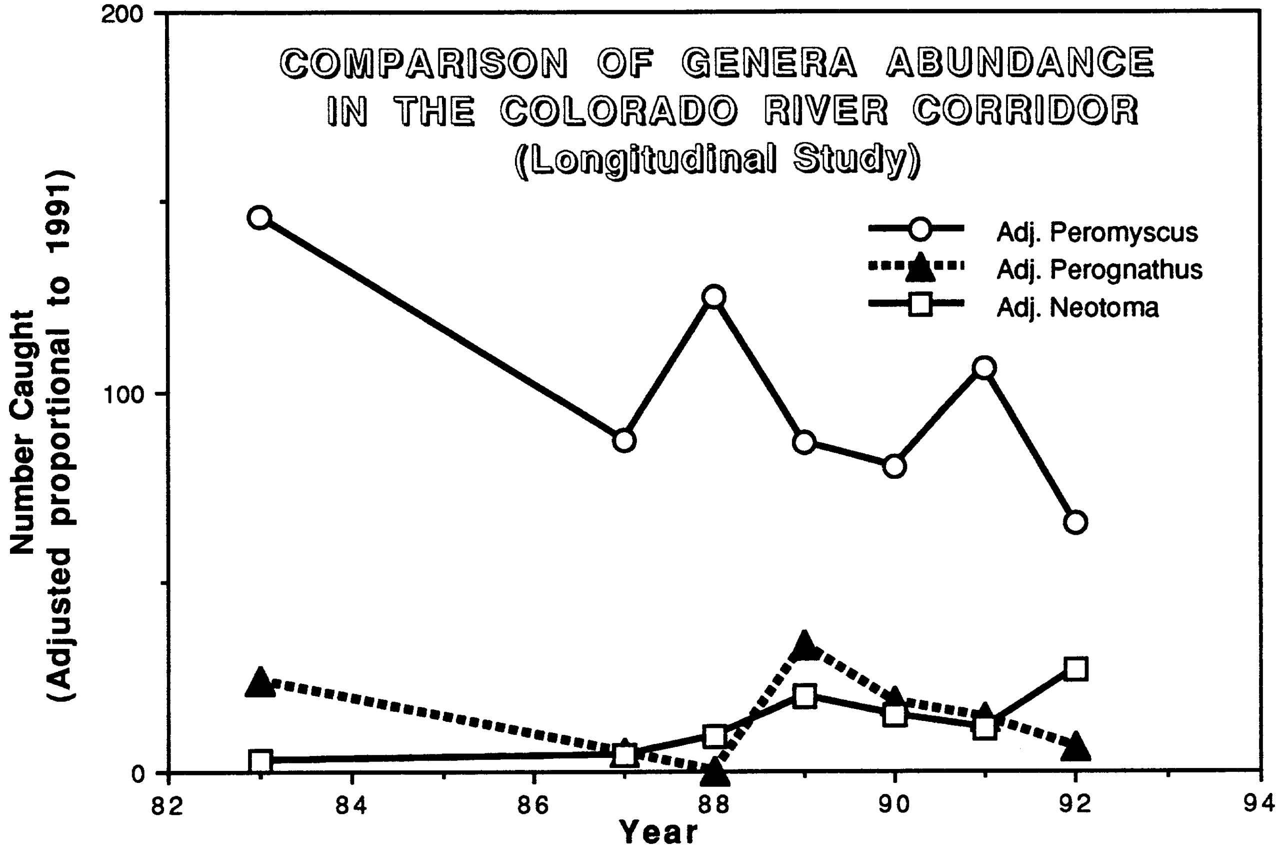

FIGURE 7-8

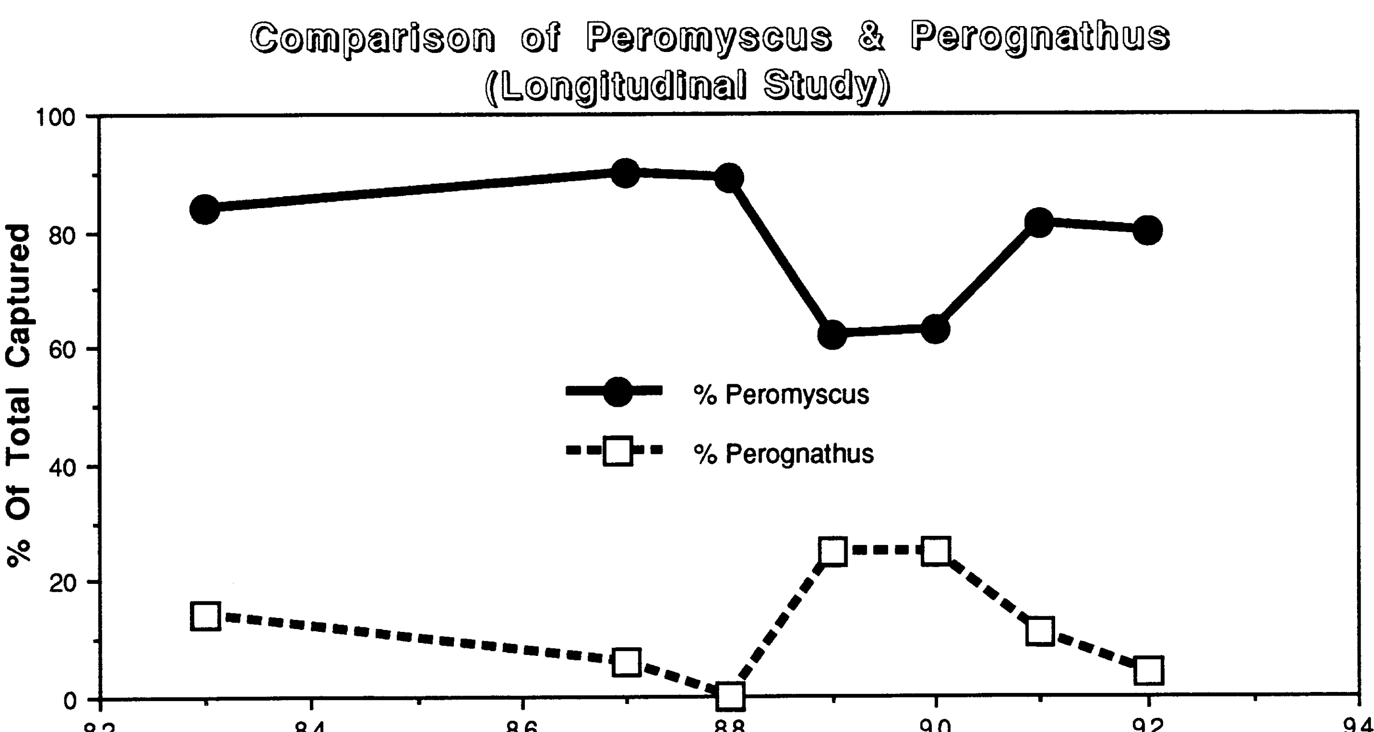

FIGURE 7-9

DISCUSSION

Figure 7-6 illustrates that researchers have always had better capture success in zone 2 than in zone 4. We expected to observe an increase in zone 4 relative to zone 2 due to the interim flows, but the data shows that zone 4 has decreased slightly over the last three years. The National Canyon beach study (Figure 7-7) has shown an increase in capture rate relative to zone 2. It now appears that the lower zone provides habitat for about half the rodents at National Canyon. These two findings suggest that each beach is unique and has been affected differently by the water release management of the dam. Zone 4 appears to be well established as a rodent habitat (Garavito and Mowery, 1991). It seems, however, that the interim flows of the last ten months has not improved the habitat for rodents in zone 4 canyon-wide, thus refuting our hypothesis.

Throughout the study the number of traps used by the researchers has varied considerably. In order to make the capture comparisons more accurate, we adjusted all values proportionately to the 1991 values. In Figure 7-8, these values indicate that *Peromyscus* have decreased significantly. *Perognathus* has declined slightly and *Neotoma* is gradually increasing. This is accompanied by the observation from ourselves and others (Stevens, 1992) that many of the trees in zone 2 are dying, and no new trees seem to be taking their place. It is unclear whether the observed decline in trees in zone 2 is correlated to the decline in *Peromyscus*. Further study may be warranted.

The inverse relationship between the capture rates of *Peromyscus* and *Perognathus*, noted in Figure 7-9, raises an interesting question. Are these two groups in direct competition? Knowing that *Perognathus* is a hardy desert dweller (Hoffmeister,1986), we looked for a correlation between weather conditions and population. Correlation analysis with May-June precipitation rates at Phantom Ranch over the study period (Climatological Data) yields an 83% correlation with *Perognathus* and a 67% correlation with *Peromyscus*. This indicates that *Perognathus* makes strong gains when May and June are exceptionally dry. Hoffmeister (1986) states that *Peromyscus* go into estivation more often during dry periods, which may account for their drop-off in dry summer years. An alternative is that *Perognathus* has an increased advantage during drought. Our data does not adequately differentiate between these two alternatives, suggesting that further research be addressed towards the question of *Peromyscus* and *Perognathus* competition.

CONCLUSION

It is evident from the data collected throughout the Colorado River corridor that zone 4 is not necessarily making gains in rodent populations. While some beaches may show gains as we hypothesized (National Canyon is one), zone 4 on the whole has lost ground to zone 2 over the last three years. This finding refutes our hypothesis. The data from the longitudinal study suggests that populations of two of the three genera (*Peromyscus* and *Perognathus*) are declining in numbers, with *Peromyscus* most significantly. Finally, the possible correlation between *Peromyscus* and *Perognathus* and climate warrants a closer look to determine whether these two genera have a future together in the Colorado River corridor.

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Chapter #8
The 1992 Lizard Census
of the Grand Canyon Riparian Corridor

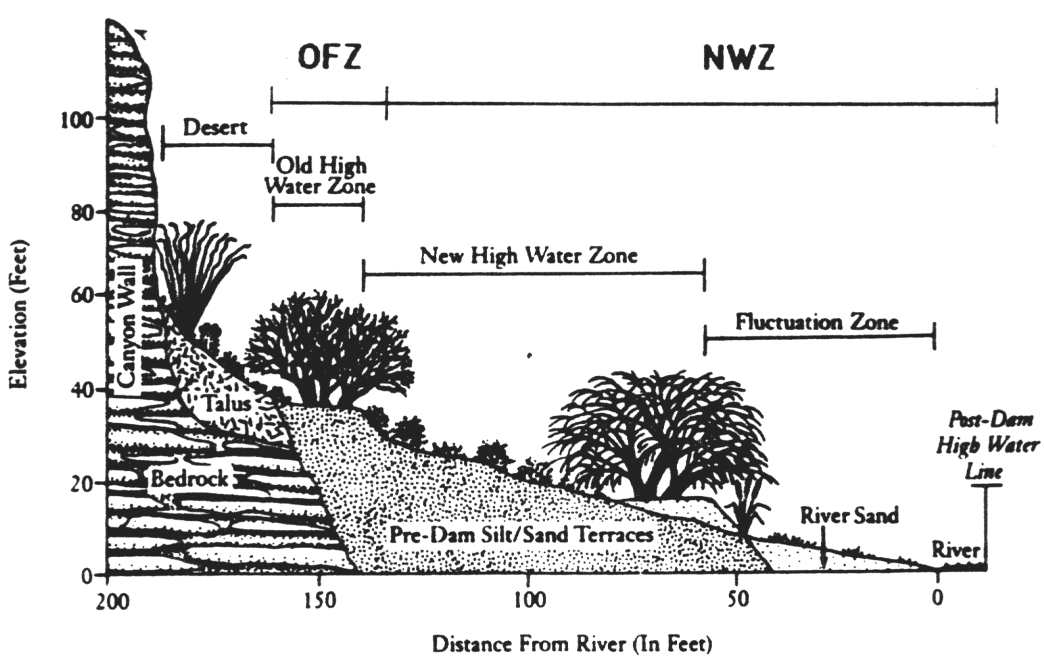
Fred Fotsch and Joe Mollica

INTRODUCTION

Lizards and other reptiles make up an important trophic level in the animal and plant ecology of the Colorado River corridor through the Grand Canyon National Park. Not only do lizards fascinate and intrigue the visitor with their varieties of colorado and curious behaviors, but they also help control large numbers of both aquatic and terrestrial insects (Janda and Jones 1991).

This study attempts to census the population of four main lizard species at various beach sites along the Colorado River. It is primarily a descriptive study outlining the numbers of each species of lizard encountered, and any unusual species of reptiles such as the Chuckwalla lizard and the Grand Canyon Rattlesnake. Descriptions of each of the four main types of lizards studied are given in the lizard identification guide.

The study outlines which riparian zones are preferred by the lizard species and determines which species is most frequently encountered. Carothers (1979) described four main vegetation zones that exist along the Colorado river corridor after the completion of the Glen Canyon dam. For ease of sampling, these four zones were combined into two main zones in which lizard species were counted. The Fluctuation Zone and the New High Water Zone were combined into the "New Water Zone" (NWZ) and the Old High Water Zone was called the "Old Flood Zone" (OFZ). See figure below.



(Adapted from Carothers, 1979 and 1991)

Lizard Identification Guide

Common Name: **Side Blotched Lizard**
Scientific Name: ***Uta stansburiana***
Study I.D. code: **UTST**
Description: The side-blotched lizard is small in size about 1 1/2 -2 1/4 inches (3.7 -5.9 cm) snout/vent length. This brownish lizard is easily identified by a bluish black blotch on either side of the chest, behind the forelimb. Males lack distinctive blue throat or belly patches. According to Pianka (1986) the side-blotched lizard is frequently found near shrubs, however Stebbins (1966) indicated a varied habitat which includes sand, rock, bushes or scattered trees.

Common Name: **Tree Lizard**
Scientific Name: ***Urossaurus ornatus***
Study I.D. code: **UROR**
Description: The tree lizard is small in size about 1 1/2 - 2 1/4 inches (3.9 - 5.6cm) snout/vent length. It is slender with a long tail, dark brown to gray, with blotched or chevron-shaped markings on its dorsal side. The adult male sports vivid blue-green or blue belly patches, with an orange, greenish, or yellow throat. Females lack belly colors: the throat is white, orange, or yellow. This lizard is usually found on dark surfaces of rocks near water, not trees as his name suggests. When approached, the tree lizard will cock its head before retreating. (Miller et al. 1982).

Common Name: **Desert Spiny Lizard**
Scientific Name: ***Sceloporus magister***
Study I.D. code: **SCMA**
Description: The desert spiny lizard is 3 1/4 - 5 1/2 inches (8.1-14 cm) snout/vent length. It has a stocky body covered with large pointed scales that have a straw yellow appearance on the head and brownish grey on its dorsal and lateral surfaces. A large black wedge-shaped marking with a light-colored rear edge is present on each side of the neck. It inhabits areas of rocks, crevices and trees and uses a "sit and wait" foraging technique. This lizard feeds on insects, other lizards and occasionally on vegetation. (Tomko 1976).

Common Name: **Western Whiptail**
Scientific Name: ***Cnemidophorus tigris***
Study I.D. Code: **CNTI**
Description: The western whiptail is 2-5 1/2 inches (5-13.7 cm) snout/vent with a slender body and a long tail. The whiptail is easily identified by the pale yellow, white or green longitudinal stripes on its dorsal surface and its overall streamlined-snakelike appearance (Miller et al. 1982). They typically prowl with a jerky gait, moving their head from side to side while protruding a forked tongue.

[All of the above descriptions were adapted from (Lew and Welden 1990, and from the Arizona Sonoran Desert Docent Handbook 1990)]

METHODS

The 1992 lizard census used the following method to estimate the density of lizards in the riparian corridor of the Colorado River from Lee's Ferry to river mile 220.

1. At each location, the river mile, location name, date, and time of day was recorded. In addition, the ambient air temperature and soil temperature in the shade was measured and recorded.

2. At each location, one observer surveyed the new high water zone (NWZ) and the other surveyed the old flood zone (OFZ).

3. The lizard density was estimated by using an encounter rate. Each observer walked in their respective zone for an interval of time. During that time interval, the number of each species of lizard encountered was recorded. The total time spent by each observer surveying the lizard population was also recorded.

4. The encounter rate was computed by taking the ratio of the number of lizard encounters to time spent surveying. The rate was recorded with the units of lizards per minute (LPM).

5. The lizard encounter rate was calculated in the OFZ and NWZ at each location with each individual species, and for all species combined.

6. Lizards were captured for identification when necessary using a noose made from monofilament line attached to the end of a willow stick.

MATERIALS

1. Site specific data sheet (Addendum)
2. Pencil
3. Thermometer
4. 3 ring note book
5. Clipboard
6. Monofilament line
7. Sharpee marker

RESULTS

The data for the 1992 lizard census is compiled in Table 8-1. The census includes eighteen sites with a total time of 1281 minutes spent surveying. In total, 208 lizards were sited.

The lizard encounter rates for the census are compiled in Table 8-2. The range in total lizard encounter rate for the eighteen sites is 0 LPM at Grapevine (mi 81.3) to .45 LPM at Carbon Creek (mi 64.5). The mean lizard encounter rate for the eighteen sites was .166 lizards per minute (LPM) with a standard deviation of .115 LPM.

The lizard encounter rate for the eighteen sites in the old flood zone (OFZ) ranges from 0 LPM at Nautiloid Canyon (mi 34.7), Grapevine (mi 81.3), and National (mi 166.6) to .142 LPM at river mile 220. The mean lizard encounter rate in the flood zone was .49 LPM with a standard deviation of .039 LPM.

The lizard encounter rate for the eighteen sites in the normal water zone (NWZ) range from 0 LPM at Grapevine (mi 8.3) and National (mi 166.6) to .333 LPM at Carbon Creek (mi 64.5). The mean was .116 LPM with a standard deviation of .094 LPM.

The mean lizard encounter rate for Uta stansburiana (UTST) was .021 LPM with an n=27. The mean lizard encounter rate for Uarosaurus ornatus (UROR) was .070 LPM with an n=90. The mean lizard encounter rate for Sceloporus magister (SCMA) was .030 with an n=39. The mean lizard encounter rate for Cnemidophorus tigris (CNTI) is 034 with an n=43. The mean lizard encounter rate for the OTHER category was .007 LPM with an n=9.

DISCUSSION

Figure 8-1 shows that the New Water Zone (NWZ) has a greater lizard encounter rate than the Old Flood Zone (OFZ). Table 8-2 shows the site with the greatest lizard encounter rate is Carbon Creek (64.5) and the least at Grapevine (81.3). Figure 8-2 shows the tree lizard Uarosaurus ornatus is most often encountered while the Side Blotched Uta stansburiana is least often encountered. Figure 8-3 shows that temperature is positively correlated with lizard encounter rate, explaining 19.8 percent of the variance. This seems reasonable for cold blooded organisms, where temperature may be related to activity. In addition, Figure 8-4 suggests that lizards are more active at about 11:00 AM and again at 6:00 PM. However, the fifth degree polynomial explains only 15 percent of the variance. This is also corroborated by observation.

Table 8-1

DATE	MILE	Site No	SITE	AIR TEMP (F)	SOIL TEMP (F)	UTST	UROR	SCMA	CNTI	OTHER	TOTAL	TIME min	Time (24 hr)
7/19/92	8	1	Badger Creek Rapids	95	101	1	0	0	0	1	2	60	13:45
7/19/92	19.8	2	L 19.8	89	94	1	5	0	2	1	9	150	17:45
7/20/92	31.8	3	Stanton's Cave	94	107	1	3	2	2	1	9	90	11:40
7/20/92	34.7	4	Naotiloid Canyon	104	98	2	4	0	4	0	10	50	13:45
7/20/92	50	5	ET/Dino Beach	91	87	0	4	0	2	0	6	100	19:12
7/21/92	52.6	6	Nankoweap Delta	99	92	0	2	8	4	5	19	70	10:15
7/21/92	64.5	7	Carbon Creek	98	91	14	7	0	4	2	27	60	17:45
7/22/92	75.5	8	Nevills	105	90	1	7	1	6	0	15	72	11:52
7/22/92	81.3	9	Grapevine (night)	92	91	0	0	0	0	0	0	60	9:30
7/23/92	93.7	10	Granite Rapid	100	92	0	3	4	0	0	7	60	11:05
7/23/92	120.2	11	Blacktail Canyon	99	97	0	7	1	0	0	8	60	19:30
7/24/92	122.8	12	Forster	99	94	0	10	4	2	1	17	60	9:05
7/24/92	138	13	Poncho's Kitchen	85	81	0	1	12	12	0	13	45	19:00
7/25/92	143	14	Kanab Creek	95	92	3	8	4	4	0	19	84	8:50
7/26/92	166.6	15	National Canyon	74	79	0	1	2	0	0	3	60	9:40
7/27/92	179	16	Lava Falls	95	89	0	0	1	1	0	2	30	11:05
7/27/92	190.2	17	Mile 190.2	95	99	0	4	0	5	0	9	50	12:35
7/28/92	220	18	Mile 220	98	92	4	24	0	7	0	35	120	9:05

Table 8-2

DATE	MILE	Site No.	SITE	OFZ (LPM)	NWZ (LPM)	Total (LPM)
7/19/92	8	1	Badger Creek Rapids	0.017	0.017	0.03
7/19/92	19.8	2	L 19.8	0.027	0.033	0.06
7/20/92	31.8	3	Stanton's Cave	0.033	0.067	0.1
7/20/92	34.7	4	Nautiloid Canyon	0	0.2	0.2
7/20/92	50	5	ET/Dino Beach	0.4	0.02	0.06
7/21/92	52.6	6	Nankoweap Delta	0.071	0.2	0.27
7/21/92	64.5	7	Carbon Creek	0.067	0.333	0.45
7/22/92	75.5	8	Nevills	0.097	0.111	0.21
7/22/92	81.3	9	Grapevine (night)	0	0	0
7/23/92	93.7	10	Granite Rapid	0.05	0.067	0.12
7/23/92	120.2	11	Blacktail Canyon	0.05	0.083	0.13
7/24/92	122.8	12	Forster	0.033	0.25	28
7/24/92	138	13	Poncho's Kitchen	0.111	0.178	0.29
7/25/92	143	14	Kanab Creek	0.071	0.155	0.23
7/26/92	166.6	15	National Canyon	0.05	0	0.05
7/27/92	179	16	Lava Falls	0	0.067	0.06
7/27/92	190.2	17	Mile 190.2	0.021	0.16	0.18
7/28/92	220	18	Mile 220	0.141	0.15	0.29

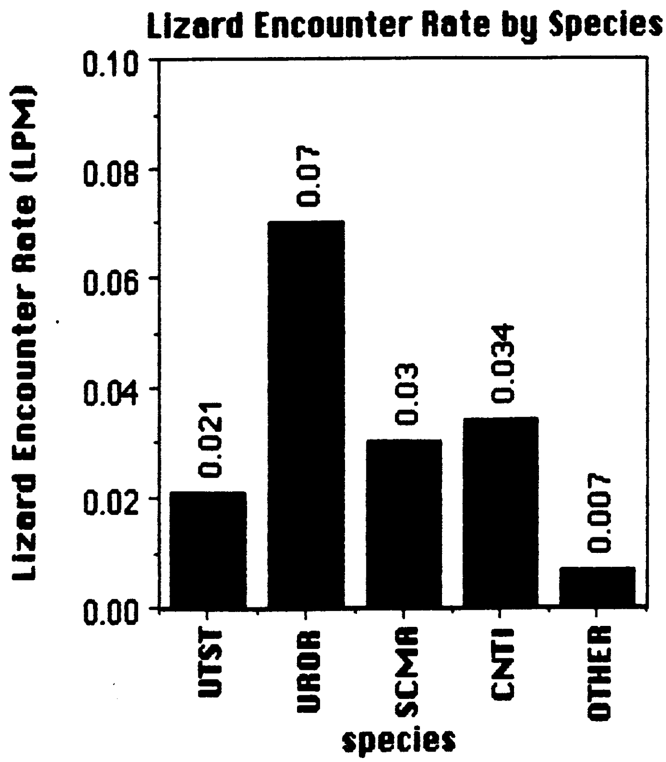


Figure 8-1

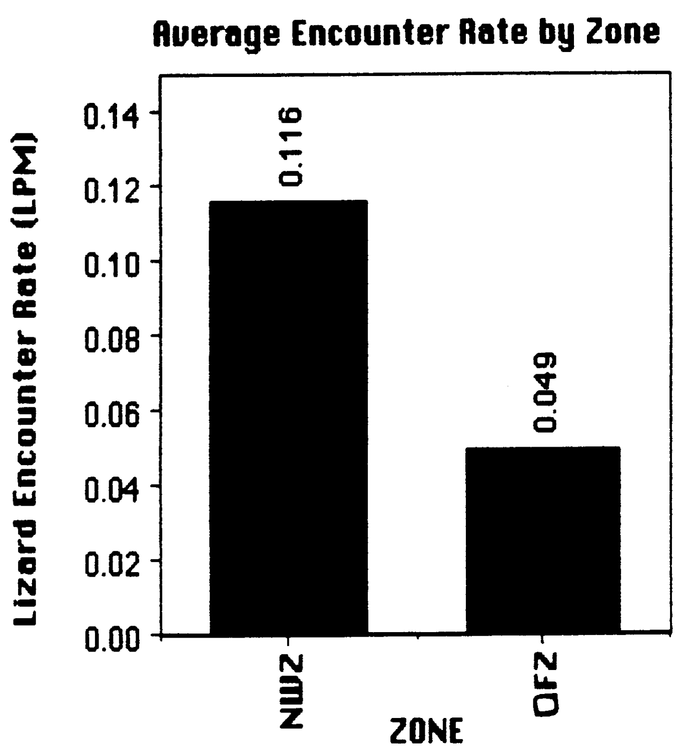


Figure 8-2

Air Temperature as a Predictor of Lizard Encounter Rate

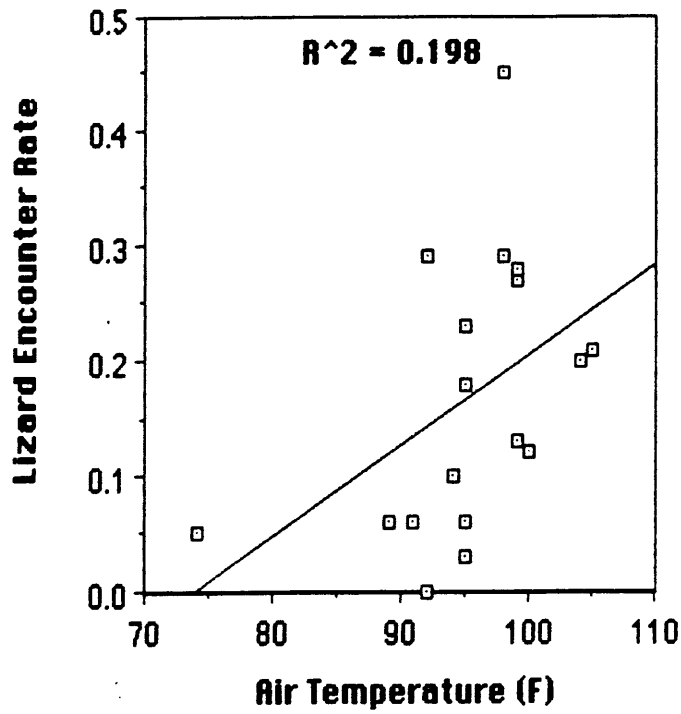


Figure 8-3

Time of Day as a Predictor of
Lizard Encounter Rate
Using a Fifth Degree Polynomial

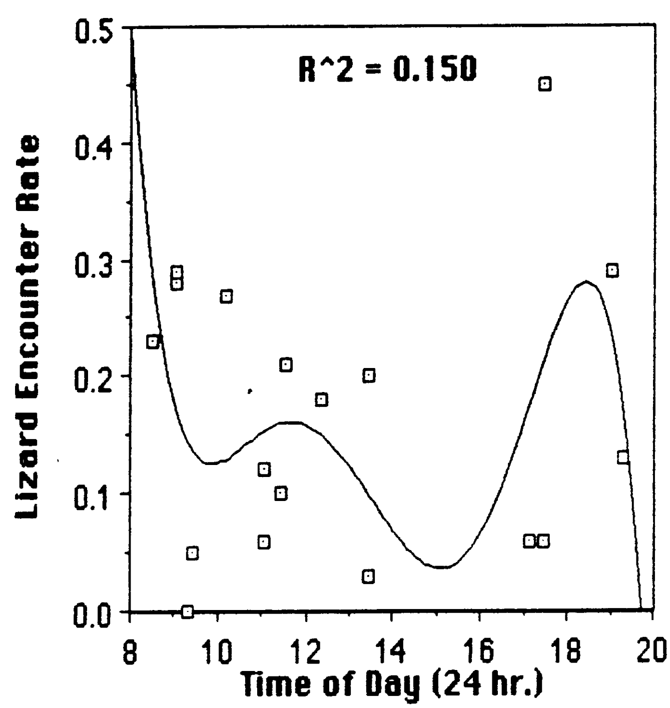


Figure 8-4

SITE SPECIFIC DATA

Collectors Name:____________________

DATE	MILE	SITE	AIR TEMP (F)	SOIL TEMP (F)	TIME START	TIME STOP	TOTAL TIME

Lizard	NWZ	OFZ	Total Numbers
UTST			
UROR			
SCMA			
CNTI			
OTHER 1			
OTHER 2			
OTHER 3			

Beach Zone Explanation:
1) NWZ = New Water Zone (10,000 -18,000cfs)

2) OFZ = Old Flood Zone (60,000cfs and above)

Beach Site Description:____________________

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Chapter 9

WATERFOWL DENSITY ALONG THE COLORADO RIVER CORRIDOR IN THE GRAND CANYON

David Thompson and Bill Blume

INTRODUCTION

Prior to the construction of the Glen Canyon Dam along the Colorado River in Northern Arizona, the Colorado River corridor was mostly devoid of riparian and marsh type vegetation. The river corridor below the old high water line was scoured by annual spring floods with mean annual flows of 86,167 cubic feet per second (cfs) (Stevens 1983). All possible nesting sites for waterfowl along this beach zone would be destroyed by the annual scouring.

The completion of Glen Canyon Dam in 1963, had a profound effect on the downstream environment of the Colorado River corridor. Since the flood years of 1983-6, when Glen Canyon Dam was forced to release water at a rate of over 90,000 cfs due to extremely high spring runoff, the dam has been managed so that the maximum flow rate never exceeds 31,500 cfs. This regulated flow has led to the establishment of a more stable riverside environment, which has developed into a diverse riparian life zone. Riverside marshes or wetlands have also developed within these riparian vegetation zones that now support sedges, cattails, and bulrushes (Westover, McKay, Brooks, & Stevens 1991), and provide suitable habitat for waterfowl which did not previously exist.

OBJECTIVES

This research was designed to provide a baseline inventory of the waterfowl, shorebirds, and raptors observed within the river corridor from Lees Ferry (river mile 0) to Lake Mead National Recreation Area (river mile 277). Particular attention was given to sightings of waterfowl broods that are using this new wetland habitat as a year round residence and biologically important breeding area. As a secondary note, we recorded the sightings of all ungulates spotted along the river corridor.

It is hoped that this information will be of value to future researchers in determining the effect of water release rates from Glen Canyon Dam (now under interim flow management) upon this newly established habitat. We hypothesized a moderate number of resident waterfowl within the river corridor, with the largest population numbers occurring in the areas of adequate wetland habitat.

METHODS

The 277 mile long section (Lees Ferry to Grand Wash Cliffs) of the Colorado River that was researched, is divided into 12 smaller units, called reaches, based upon geographic location (Table 1). The study area includes the entire river corridor and was carried out daily from sunrise to sunset. All sightings of waterfowl, shorebirds, and raptors were recorded while traveling on the raft and while camping along the river.

Research team members were responsible for sighting all waterfowl, shorebirds, and raptors and identifying each of the species noted. There was some concern about the correct identification of certain species of waterfowl that may have created certain anomalies, therefore all unidentifiable species were recorded in a separate category. Sightings were carried out with the aid of binoculars and various field guides (Udvardy 1987; Wylie and Furlong 1978) to help with inconsistencies in identification. All information was recorded on the data record sheet (Fig. 1); information included mileage, time of sighting, species identification, number of species, behavior, and special comments or characteristics (i.e. sightings of hatchlings or duck broods). Particular attention was concentrated along the identified wetland areas within the river corridor, as defined by Phillips et al (1977).

MATERIALS

<u>The following equipment was used to collect data</u>: Each team member required a complete set of the following material stored in a easily accessible waterproof container.

Waterproof Binoculars
Identification Guides
Data Record Sheets (Fig. 1)
Three Ring Binders
Pencils & Erasers
Small Dry Bag (for storage of data sheets)

RESULTS

The following data was compiled on an eleven day river trip from July 19-29, 1992. During this period the Glen Canyon Dam was releasing water under the "Interim Flow" management plan. This management plan regulates the maximum flow not to exceed 20,000 cfs and minimum flows not to fall below 5,000 cfs, with an average daily discharge no lower than 8,000 cfs.

Table 1 shows the river reaches or units into which the Colorado River was divided for our research. Each reach is titled by a unique geographical feature. Table 2 is a complete summary of all sightings. Entries include the date and time of sighting, reach, species and common name of all sightings. Those species that were unidentifiable were listed by Family name. Data was recorded on the field data sheet shown in Figure 1.

The main objective of this research was to establish baseline data, which is represented in figures 2 through 5. The number of waterfowl sightings per reach is depicted in Figure 2. The most predominate waterfowl species was *Anas platyrhynchos*, which represented 50% of all sightings (32 out of 64). Figure 3 depicts the number of shorebird sightings per reach. Raptor sightings are represented in Figure 4 and all ungulate sightings are shown in Figure 5. The percent of adult Mallard Ducks sighted to Mallard Ducklings is represented in the pie graph, Figure 6. 21.88% of all mallards sighted were hatchlings and 78.12% were adults.

The existence of developing wetland habitat is well documented (Phillips 1977), but the number of species using the habitat is not adequately documented. In spite of the fact that no previous data exists for comparison purposes, our data raises some interesting questions which future research teams may want to examine. We hypothesized that the highest concentration of waterfowl sightings would occur along the reaches with the most suitable wetland habitat, but our data concluded a dramatic decline in waterfowl sightings after reach number four. The geologic properties of the river corridor's strata could explain for the decline in sightings. More resistant rock layers within the Inner Gorge creates an environment more typical of swift moving water, which is not supportive of wetland habitat, and the waterfowl have difficulty navigating these river areas.

Our team did not sight any eagles during the eleven day research trip, but this could be due to seasonal eagle use and the lack of spawning trout during the summer months which the eagles use as a major food source.

MILEAGE SEQUENCE ________ MILE TO ________ MILE DATE: ________

MILE	TIME	SPECIES SIGHTED	NUM.	BEHAVIOR	SPECIAL COMMENTS
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					

FIGURE 1. DATA RECORD SHEET

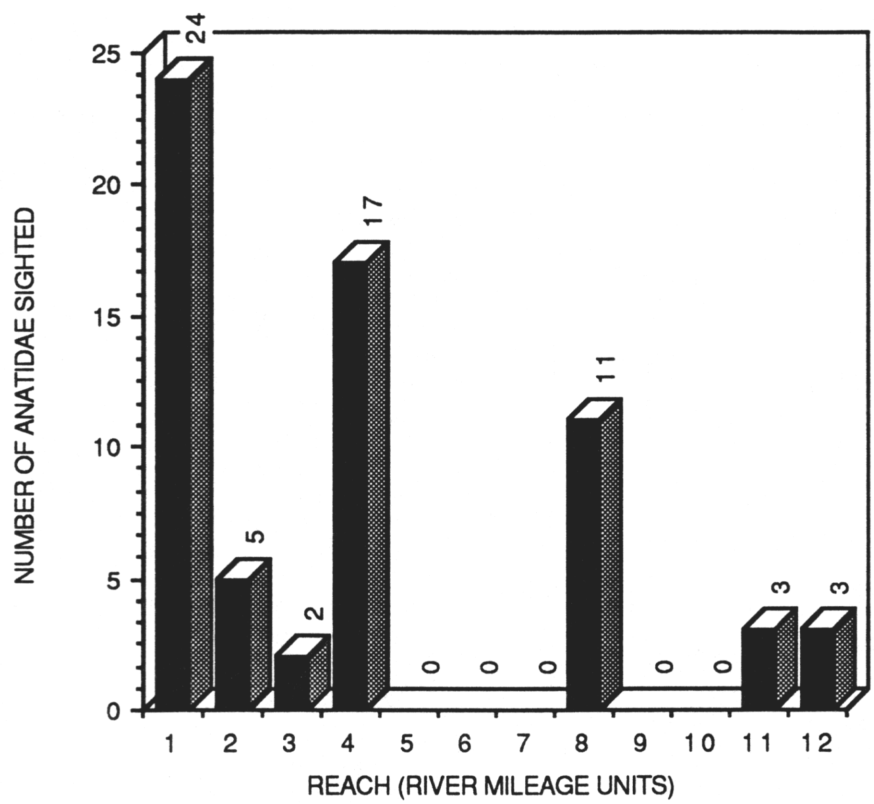

FIGURE 2: NUMBER OF WATERFOWL SIGHTINGS PER REACH

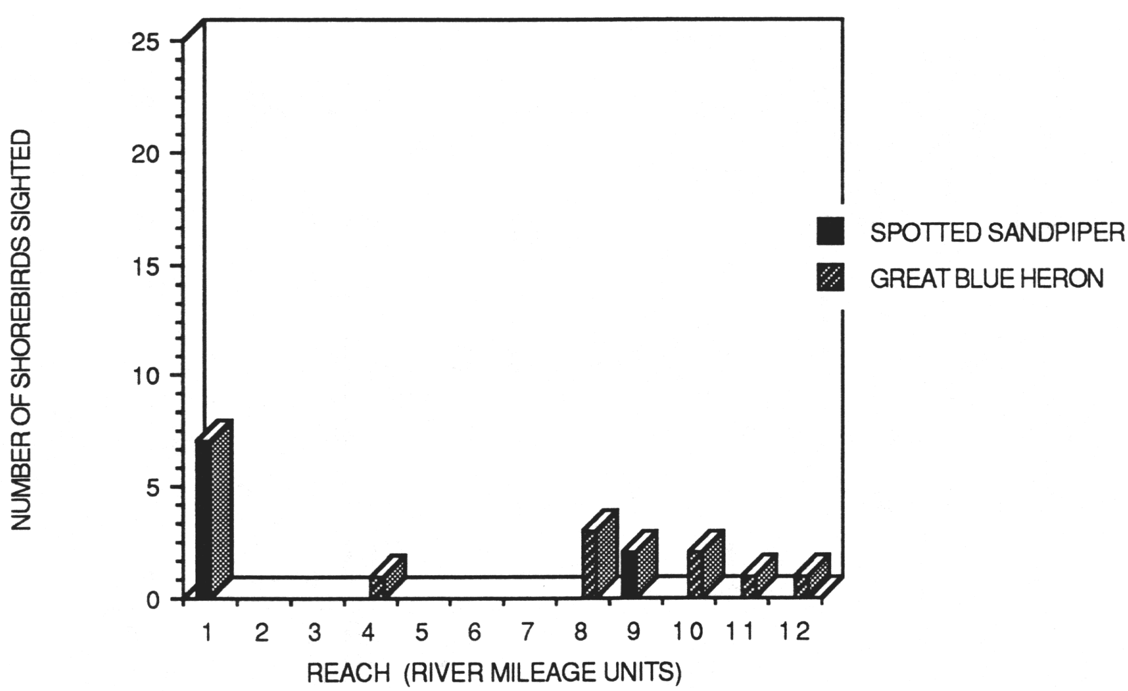

FIGURE 3: NUMBER OF SHOREBIRD SIGHTINGS PER REACH

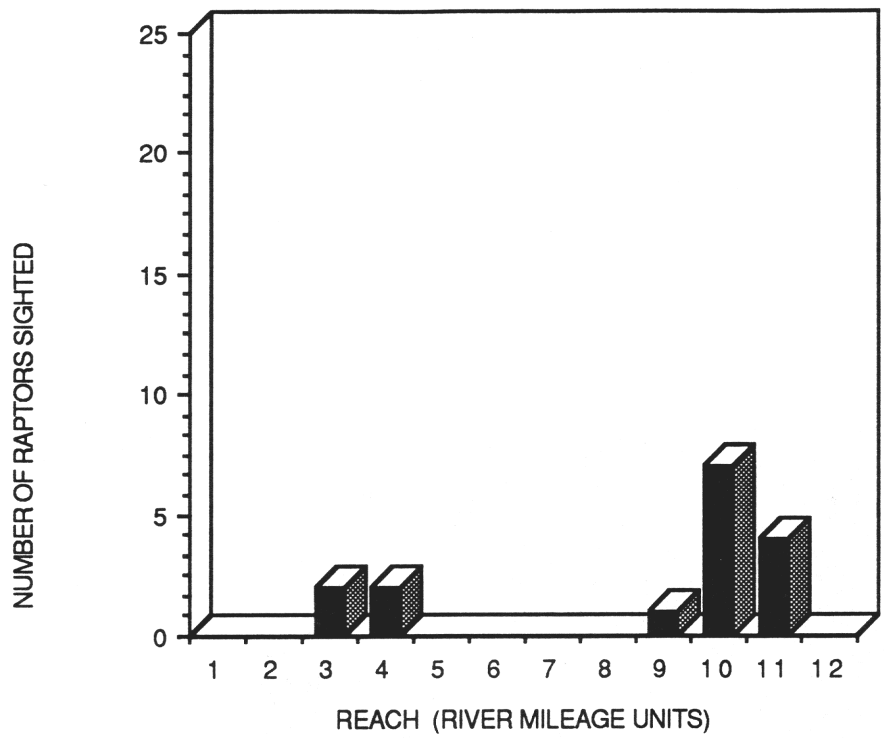

FIGURE 4: NUMBER OF RAPTOR SIGHTINGS PER REACH

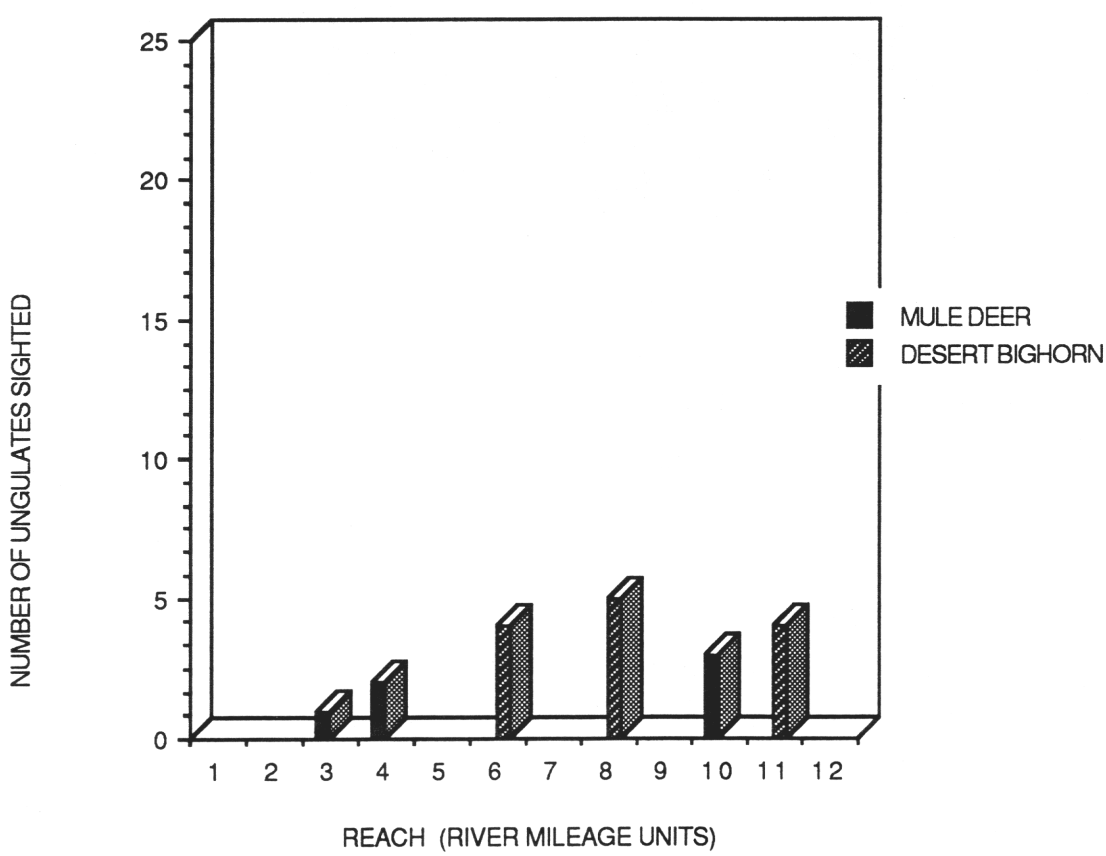

FIGURE 5: NUMBER OF HOOFED ANIMAL SIGHTINGS PER REACH

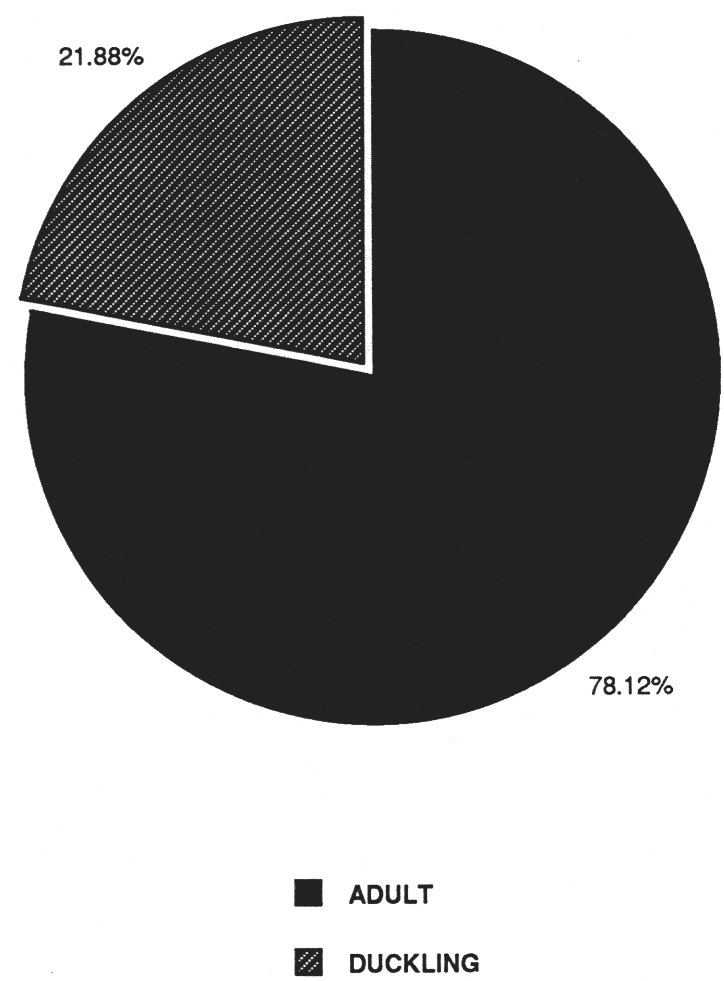

FIGURE 6: PERCENT OF ADULT MALLARD DUCKS SIGHTED TO MALLARD DUCKLINGS

TABLE 1. REACHES (RIVER MILEAGE UNITS)

REACH	RIVER MILEAGE	GEOGRAPHIC LOCATION
1	0 - 11	Top of Soap Creek
2	11 - 22.5	Top of Redwall
3	22.5 - 39	Marble Canyon Dam Site
4	39 - 61	Little Colorado River
5	61 - 76.5	Hance Rapid
6	76.5 - 116.5	Elves Chasm
7	116.5 - 125.5	Alarcon Terrace
8	125.5 - 140	140 Mile Canyon
9	140 - 157	Havasu Creek
10	157 - 213	Pumpkin Springs
11	213 - 240	Seperation Canyon
12	240 - 277	Lake Mead Recreation Area

TABLE 2. AVIAN SPECIES SIGHTED ALONG COLORADO CORRIDOR

DATE	REACH	TIME	NUM	SPECIES	COMMON NAME
7/19/92	1	12:44	6	*Mergus merganser*	Common Merganser
7/19/92	1	12:50	1	*Anas platyrhynchos*	Mallard
7/19/92	1	12:52	5	*Unknown Anatidae*	Unknown Duck
7/19/92	1	12:53	6	*Anas platyrhynchos*	Mallard
7/19/92	1	12:54	1	*Aythya affinis*	Lessr Scaup
7/19/92	1	12:59	5	*Anas strepera*	Gadwall
7/19/92	1	15:05	7	*Actitis macularia*	Spotted Sandpiper
7/19/92	2	15:40	1	*Aythya affinis*	Lesser Scaup
7/19/92	2	15:45	1	*Unknown Anatidae*	Unknown Duck
7/19/92	2	16:20	2	*Anas cyanoptera*	Cinnamon Teal
7/19/92	2	16:30	1	*Bucephala albeola*	Bufflehead
7/20/92	3	11:04	1	*Buteo jamaicensis*	Red-tail Hawk
7/20/92	3	12:24	1	*Falco sparverius*	American Kestrel
7/20/92	3	16:35	1	*Odocoileus hemionus*	Mule Deer
7/20/92	3	16:40	2	*Anas platyrhynchos*	* Mallard

TABLE 2 CONTINUE. AVIAN SPECIES SIGHTED ALONG COLORADO CORRIDOR

DATE	REACH	TIME	NUM	SPECIES	COMMON NAME
7/20/92	4	16:55	3	*Anas platyrhynchos*	Mallard
7/20/92	4	16:56	3	*Anas platyrhynchos*	** Mallard
7/20/92	4	17:25	2	*Odocoileus hemionus*	Mule Deer
7/20/92	4	17:33	7	*Anas platyrhynchos*	*** Mallard
7/21/92	4	08:00	1	*Ardea herodias*	Great Blue Heron
7/21/92	4	10:30	1	*Anas platyrhynchos*	Mallard
7/21/92	4	10:35	3	*Anas platyrhynchos*	Mallard
7/23/92	6	18:05	4	*Ovis canadensis*	Desert Bighorn
7/24/92	8	12:30	1	*Ardea herodias*	Great Blue Heron
7/24/92	8	12:47	1	*Ardea herodias*	Great Blue Heron
7/24/92	8	13:00	2	*Ovis canadensis*	Desert Bighorn
7/24/92	8	13:05	5	*Mergus merganser*	Common Merganser
7/24/92	8	13:10	3	*Ovis canadensis*	Desert Bighorn
7/24/92	8	16:30	1	*Ardea herodias*	Great Blue Heron
7/24/92	8	16:31	6	*Mergus merganser*	Common Merganser
7/25/92	9	10:12	2	*Actitis macularia*	Spotted Sandpiper
7/25/92	9	13:02	1	*Falco peregrinus*	Peregrine Falcon
7/26/92	10	16:30	6	*Cathartes aura*	Turkey Vulture
7/27/92	10	09:50	1	*Ardea herodias*	Great Blue Heron
7/27/92	10	09:55	1	*Ardea herodias*	Great Blue Heron
7/27/92	10	13:18	3	*Odocoileus hemionus*	Mule Deer
7/27/92	10	15:58	1	*Accipiter gentilis*	Goshawk
7/27/92	11	17:50	1	*Ardea herodias*	Great Blue Heron
7/27/92	11	17:50	3	*Anas platyrhynchos*	Mallard
7/28/92	11	08:55	1	*Pandion haliaetus*	Osprey
7/28/92	11	09:00	2	*Buteo jamaicensis*	Red-tail Hawk
7/28/92	11	10:13	4	*Ovis canadensis*	Desert Bighorn
7/28/92	11	10:28	1	*Buteo jamaicensis*	Red-tail Hawk
7/28/92	12	19:35	3	*Anas platyrhynchos*	Mallard
7/29/92	12	07:05	1	*Ardea herodias*	Great Blue Heron

Notes:

* One adult hen mallard with one mallard chick
** Two adult hen mallards and one mallard chick
*** Two adult hen mallards and five mallard chicks

CONCLUSION

The development of new riparian habitat along the Colorado River does seem to be attracting nesting waterfowl as witnessed by the percentage of ducklings sighted (Figure 6). Further research will need to be conducted during all seasons to adequately represent the waterfowl, shorebird, raptor, and ungulate populations living within the Colorado River Corridor and determine if their populations will remain stable, decline, or increase. It is hoped that the base line data collected on this trip will be of value to future researchers interested in exploring the many complex relationships between these animals, and the management of Glen Canyon Dam which affects the entire downstream river corridor.

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Chapter 10

BAT ACTIVITY ALONG THE COLORADO RIVER WITHIN THE GRAND CANYON

Laura Craft and Charles Rey

INTRODUCTION

In review of research, bat studies have intermittently been conducted in the Grand Canyon from 1931 until the present. The most extensive study seems to have been from 1969 until 1978, when Ruffner, Czaplewski, and Carothers noted species of bats from river mile 0 to river mile 274. During this research period the bat species account included the Yuma myotis, California myotis, Silver-haired bat, Western pipistrelle, Townsend's big-eared bat, and the Mexican free-tailed bat.

World wide, bat populations are declining because of human vandalism, disturbances of roost sites, careless research, mining of guano for nitrates, and loss of habitat (Tuttle, 1988). The Park Service has limited river trips to 16,500 passengers per year (Stevens, 1983); many of these visitors do not have the time to explore the nearby caves, side canyons, and rock crevices in which the bats are roosting. Trails that are used by large numbers of hikers are limited, therefore, few people actually get to an area where their presence is a problem. The bats along the Colorado River within the Grand Canyon are a protected group because of the limitations established the Park Service, the physical boundaries, and the remoteness of the canyon.

Bats are an integral part of the canyon ecology. In general, one bat can eat up to 600 mosquitoes in an hour (Tuttle,1988). When 25 bats are seen within an hour, a common accordance in the canyon, an assumption can be made that 150,000 mosquitoes have been eaten: that means there are less mosquitoes to bother the campers. Just as bats are predators,they are preyed upon by birds of prey, lizards, and mammals.

The following report is a baseline study, for THE COLORADO RIVER INVESTIGATION XI, to note where and when bats are active and which species are present along the Colorado River corridor.

METHODS

The objective of this project was to observe the activity of bats along the river corridor and to identify the species of bats which were being observed. During the ten nights in the canyon, eight evenings were dedicated to the project. Mist nets were set up on six of the eight evenings. At National Canyon, the second night spent at this beach was designated as as all night net study. There were two researchers involved in the observations and removal of bats from the nets, while two volunteers aided in holding lights and checking nets when researchers were working with captured bats.The following methods were used in this study:

A. Observations

Observation time was from 19:00 to 22:00. Morning observations were conducted from 04:30 to 06:00. Observers would sit by the net or on the beach with the data sheet, watch, clipboard, pencil and flashlight. A sketch of the beach would be made on the data sheet, underneath 'location where seen'. Observers would record the number of bat sightings during half hour intervals (Because the observers may have seen the same bat several times, or several bats a few times, data was recorded as the numbers of bat sightings within the given time interval). Observers would note flying patterns and general observations. After dark, flashlights were used to search for bats.

B. Mist nets

The net site was determined before dusk. Dry washes coming out of side canyons seemed to be the flyways and were the most productive areas for capture. A Brunton compass was used to identify the exact net location for further studies. Rebars were hammered into the ground and the poles slid on top. The mist net was unfolded and looped onto the poles. Sometimes rocks were placed at the base of the poles or guy ropes were used to increase stability and tautness. The net was not raised until researchers were ready to make observations. The data sheet was completed, noting time and location. After dark, the net was scanned every few minutes with a flashlight. During the all night net study, researchers slept near the net with an alarm clock and the net was scanned every half hour until 24:00,.and then scanned every hour until 04:30.

When a bat was caught in the net, the direction of entry was determined. With gloved hands an observer carefully grasped the body of the bat, extending a thumb up underneath the chin. The free hand was then used to pick the net off of the bat. A person would lightly hold the bat, while another watched the net for more incoming bats. Measurements of the ear, tragus, forearm, wingspan, total length, calcar, and tail were taken. The tail was looked at carefully to note any relationship with the interfemoral membrane. Facial features, fur color, and any other unique traits were described in writing. The bats were weighed by placing them into a pre-weighed Ziploc baggy which was clipped onto a Pescola scale. The bat's weight was found by subtracting the bag weight from the total weight. When there was more than one bat to process, the bats were kept in a cloth bag which was moistened and hung on a limb for air circulation. After being processed, bats were released by placing them on a ledge or tree limb. If a lactating female was caught, a quick descriptions was made and the bat was released. When possible, photographs were taken of captured bats.

When bat activity decreased, the nets were taken down. Early morning net capture was cancelled because researchers felt it was too stressful for the bats to be able to find safety before direct sunlight hit the walls of the canyon.

MATERIALS

Brunton compass
data sheets (table 2 and 3)
pencils and sharpener
clipboard
8m mist net, terylene nylon,mesh size of 36mm
2-9ft poles
2 3/8" rebar
leather gloves
5 cloth bags with pull string (10"x10")
3 meter tape measure
Pescola scale
Ziploc baggies
bat taxonomic key
flashlight, headlamp
6v lantern battery
spare bulbs
guy ropes, at least 4 to 5m

Later in the evening, bats were seen making quick turns to the side, up or down.

The differences of bats were noted by the size and wing beats. What were identified as Western pipistrelles (*Pipistrellus hesperus*), had small bodies and the wing beats were very fast. The bats identified as pallid bats (*Antrozous pallidus*), had large bodies and wingspans, with the fur appearing to be a light tan or blond color. When these bats flew directly above, with a slow steady beat, the large ears could be seen. The other clue to the differences was time. The pipistrelles were out in the early evening, followed by the pallid bats, who were heard making their clicking and squeaking noises. These noises were not heard until 20:00. At one time noises could be heard constantly for ten minutes; when a light was shown in the direction of the noise, a pallid bat was circling the net.

At mile 50, 64.5, and 120, there were successful nettings. At mile 50, a pallid bat was caught in the net. As the researchers worked on removing the bat, it screeched a distress call. Within five minutes there was a pipistrelle in the net, followed by two more pallid bats. As the bats were removed, several others were seen circling above the net. It is believed that the distress call interested the other bats. The net session at mile 64.5 produced one pipistrelle and two pallid bats. One of the pallid bats was lactating, so she was released immediately. No bats were captured in the evening at mile120. The next morning, at the same site, a pipistrelle was captured. This bat was quickly identified and taken to a ledge to be released*. At the five other sites, the bats were not flying into the net; instead they would fly up to it and over the top. On many occasions they would fly up to the net then turn sharply at the last minute.

About one mile up North Canyon, at mile 20.5, two dead pipistrelles were found in a clear pool. Hoffmeister (1971) has observed pipistrelles chasing insects so intently that they fly right into a pond. From there they have difficulty getting out, and subsequently drown. A dead pallid bat had been found floating against the river boat at the Carbon Creek campsite, at river mile 64.5. The act of chasing insects or getting too close to the water may have been the reason for this animal's death. A Mexican free-tailed bat (*Tadarida brasiliensis*) was found alive, in the sand toward the back of Poncho's Kitchen. Twenty minutes before, a bat had been seen fluttering near the ceiling of the overhang.

* Upon being released the bat crawled deeper into the crack but at the same time a spiny lizard ran up the ledge and grabbed at the bat. The lizard did not have a good hold on the bat so the bat tried to climb into

RESULTS

Table 10-1 and Figure 10-1 both display times at which bats were seen. The time with the highest numbers of sightings is declared the most active part of an evening. The darker the evening became during observing the harder it was to count bats. Although flashlights were used, discrepancies were surely unavoidable.

Figure10-2 displays the percentage of bat species encountered. This included net capture, bats found on the ground, and deceased. Five pallid bats and four pipistrelles were captured in the net. Two pipistrelles were found dead at river mile 20.5, one mile up North Canyon, in a clear pool. A pallid bat was found at river mile 64.7, Carbon Creek, in the river. One Mexican free-tailed bat was found alive in the sand at river mile 136.6, Poncho's Kitchen.

Table 10-2 was used to record bat identification notes and measurements. Table 10-3 was used to record time, habitat, location of net or observers, number of bat sightings, and general observations

DISCUSSION

Besides noting times, numbers of bat encounters and species, the researchers also collected data on net locations, climate and general observations.

It was determined after the first night that nets were best set up in dry washes, which seemed to be flyways from upper side canyons to the river. Tamerisks and mesquite trees were used, when possible, to camouflage poles. Distance of net from water was noted, but this did not seem to have an affect in the dry wash locations.

During windy evenings the net was blown and the bats did not fly near it. Yet, bats were seen flying higher in the sky. The one evening in which rain fell, the mist net was not set, and the bats were seen to be flying near canyon walls and low to the ground.

The observation that were recorded seemed to be common and similar to descriptions found in the literature reviewed. When the bats were first seen in the evening, they were coming straight down the flyways, towards the river. The bats dipped low above water that was in an eddy. Some bats were seen flying low over more turbulent water.

	# of bats	Time Began	Time Ended
1	7.000	19:00	19:30
2	76.000	19:30	20:00
3	109.000	20:00	20:30
4	17.000	20:30	21:00
5	19.000	21:00	21:30
6	36.000	21:30	22:00
7	4.000	22:00	22:30
8	4.000	22:30	23:00
9	1.000	23:00	23:30
10	2.000	23:30	24:00
11	0.000	24:00	1:00
12	2.000	1:00	2:00
13	0.000	2:00	3:00
14	0.000	3:00	4:00
15	2.000	4:00	5:00
16	32.000	5:00	5:30

Table10-1. Night Bat Observation

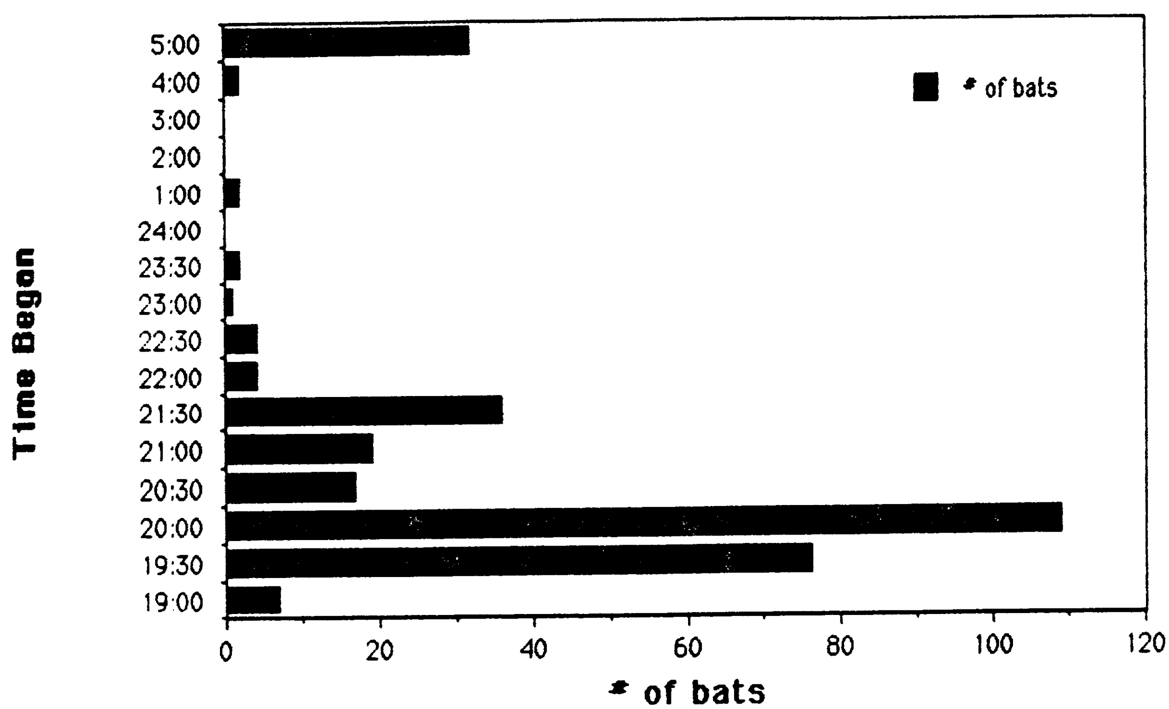

Figure10-1. Night Bat Observation

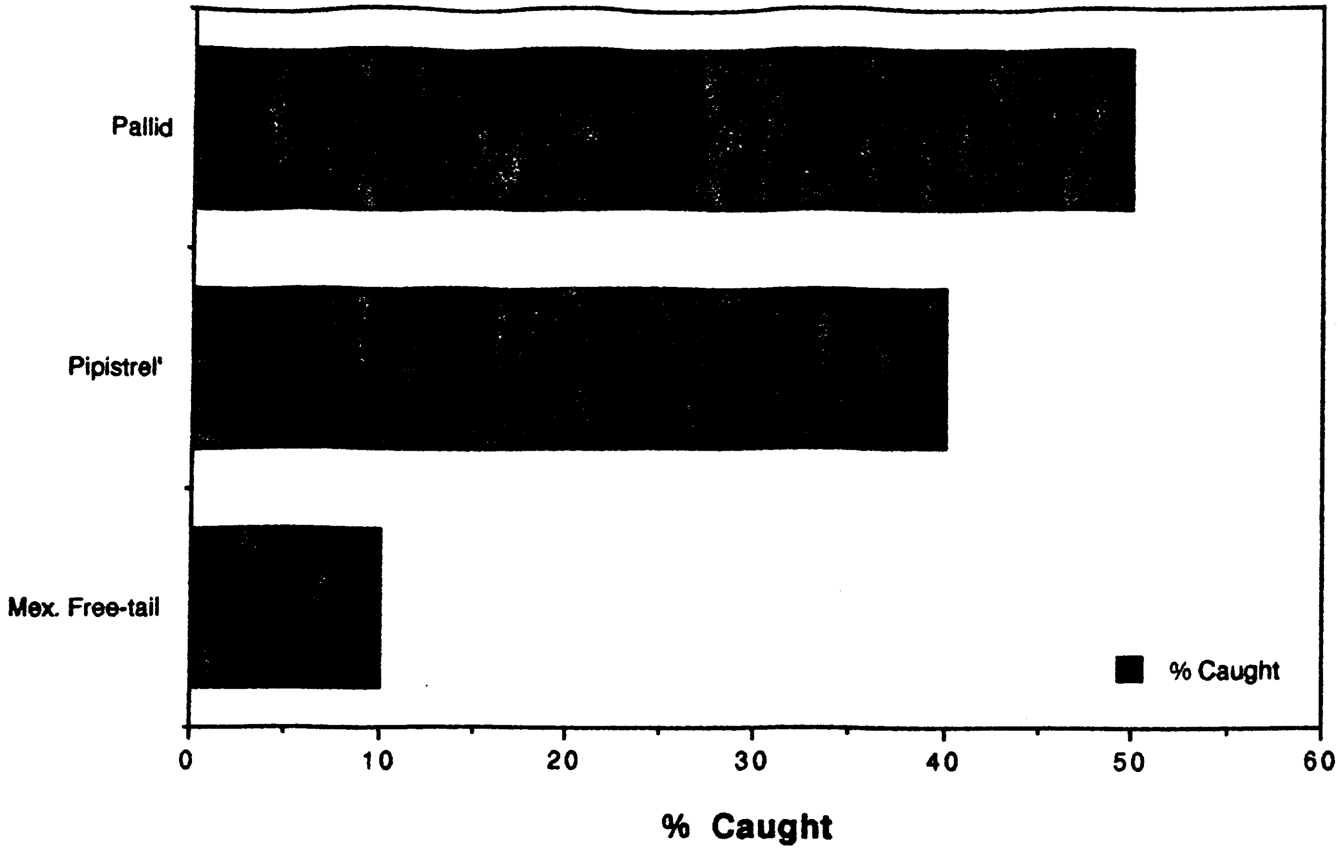

Figure 10-2. Bats Caught

Bat ID sheet & measurements

	Date & Time	Facial Descrip.	Tail Descrip.	Fur Descrip.	Sex	Total Length	Ear/ Tragus
1	9-21-92,8:35	Puffy cheeks	3mm pastmem	brown	male	70mm	27mm
2	8:45	same	enclosed	brown	female	95mm	
3	8:50	black	enclosed	light brown	male	40mm	.04mm
4							
5	7-25-92,5:30	black	enclosed	light brown	male	35 mm	9 mm/ 2 mm
6	7-25-92,6:00	Wrinkled lips	enclosed	Dark grey	male	86mm	10mm/10mm

Bat ID sheet & measurements

Forearm	Calcar	Wingspan	Weight	Specie
57mm	30mm	145mm	not available	Pallid
			31.5g	Pallid lactating-freed
30mm	15mm	67mm	16.5g	Pipistrel
31mm	3mm	76mm	15g	Pipistrel
24mm	18mm	30mm	7.5g	Mex. Free-tail

Table 10-2. Bat ID and Measurements

te
ile ______ Moon Phase ______

Bat Activity Data Sheet

Page ______

Time(24hrs)	Temp	Habitat + Vegetation Nearest water (metrics)	Location where Seen or net site	Location of observer

# of bats	Observations	Key
		Time in 24hrs. Temp in C° and F° # of Bats - tally marks Tamerisk - T dry wash - dw marsh - m sand bar - sb along walls - aw base of cliff - bc

Table 10-3

the crack again. The bat was then taken up the canyon and set on a ledge. Once again the spiny lizard came towards the bat. This time the bat was taken far up into the canyon and released onto a high ledge.

CONCLUSION

With the methods and time given in this project, the researchers felt as though they accomplished their goals. The mist nets were helpful in capturing some species of bats; however, not every net site was successful. This was possibly due to the time at which nets were set being too late, to the vegetation not being high or dense enough, or too much human activity making the bats cautious.

More research needs to be conducted. Northern Arizona University-Special Collections, Museum of Northern Arizona, and Earl E. Spamer's Bibliography of the Grand Canyon and Lower Colorado River, had very little up-to-date information on bats in the Grand Canyon. The bats along the river are a special group, as mentioned in the introduction; they need to be monitored annually on distribution and occurrence of species. This information needs to be published and made available for management considerations.

The pallid and pipistrelle bats are very active along the river. It may be comforting to know that these bats are out eating scorpions and mosquitoes, which are abundant in campsites. Because these unwanted arthropods are being controlled by the bat populations, visitors can be sure to appreciate the exterminators of the night. Unlike the misconceptions some people may have about bats (i.e.,all bats have rabies or bats like to get into human hair), these researchers did not observe a single bat which may have shown behaviors linked to rabies,nor did any of the Grand Canyon Experience participants have a bat become tangled in their hair. Instead, the whole group enjoyed watching the bats fly above, silhouetted against the evening sky.

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CHAPTER II

SIZE, SHAPE AND COMPOSITION OF BEACH SAND FROM SELECTED SITES ON THE GRAND CANYON

Dana J. McCutcheon

INTRODUCTION

Deposition and erosion are two of the major factors at work in the Grand Canyon river corridor. This investigation is an extention of several studies conducted in 1983 under the supervision of Frank Lojko and others. In addition to the study in 1963, a comprehensive study was completed in 1986 to determine if any significant trends in erosion or deposition of beach sand could be determined. This year's study will determine what changes, if any, have occurred since these studies. Eleven beaches, only one of which had no previous data, are to be compared for changes in mean grain size. Shape and composition are to be compared with previous data, although, since the flood of 1983, most beaches are composed of new beach deposits.

The last part of this investigation examines sedimentary structure and the conditions that may have produced them, on four beaches between Lee's Ferry and Phantom Ranch.

OBJECTIVES

The objectives of this study are to determine if there are any significant changes in sand grain size, shape, and composition on selected beaches in the Colorado River Corridor from Glen Canyon Dam to Lake Mead. If so, what might the causes and implications be?

SAMPLING

This investigation involved the identification of mean grain size, shape and composition of 11 beaches, 10 of which have been previously studied for mean grain size.

BEACH	MILE
*Badger Creek Rapid	8
*Nautiloid Canyon	34.7
*Nankoweap	53
*Little Colorado River	61.5
*Nevills	75.5
*Grapevine	81.3
-Granite Rapid	93.7
*Bass Camp	108.3
*Poncho's Kitchen	136.4
*National Canyon	166.6
*Mile 220	220

* repeated from 1986
\- repeated from 1983

All samples, with the exception of one, for grain size, shape and composition were collected on a transect set by the Human Impact Investigation. The sample collected from the Little Colorado River was a random sample from the beach above the river confluence.

To study the sedimentary structures and the conditions under which they may have formed, trenches were dug at the following beaches: North Canyon, Awatubi, Nevills, and Grapevine. At Mile 19, a secondary trench was dug perpendicular to the first and parallel to the shoreline, to determine the true dip of one of the beds.

MATERIALS

GRAIN SIZE

small whirl packs
40 meter tape for transect measurement
Brunton compass
permanent marker
balance scale
graduated standard sieve set #18-#270 with pan

GRAIN SHAPE AND COMPOSITION

glass petri dish
round paper disk (filter paper)
red pen
stereoscope
probe
magnetic rod pen

SEDIMENTARY STRUCTURE

shovel
sketch paper
camera
small whirl packs
small measuring tape

METHODOLOGY

GRAIN SIZE

Samples were taken from previously designated study areas for valid size comparisons to be made. Transects set by the Human Impact Investigation were used to determine each site. Records were kept of previous transect meter reading and wherever possible samples were taken from these locations. Each sample was collected in a small whirl pack (100 gms. or less).

Samples were weighed and then sieved using a standard sieve series from #18 to #230 (0 to 4.0 phi size). The pan at the bottom collected any particles finer than 4.0. Each fraction was weighed and its percent of the total fraction was determined. A cumulative percent total was then graphed and the mean phi size was determined, using the following example:

$$\frac{16\text{ phi} + 50\text{ phi} + 84\text{ phi}}{3} = \text{mean phi size}$$

SHAPE AND COMPOSITION

Each sand sample collected was observed microscopically using an American Optical stereoscope. A 10 cm. pyrex glass petrie cover dish was used to study the samples. A white circular disk with a fine red line drawn to bisect the white disc was taped to the bottom of the dish. This red line served as a reference line. Each sample was shaken for one minute and then a random number of grains were added to the petrie dish for study. The first 50 grains in contact with the red line were counted from left to right. The shape and composition of each grain was recorded. Data was compiled for percent of each shape, angular, sub-angular, sub-round and round, according to the Folks scale, as well as for composition of grains.

The petrie dish methodology was pre-tested for the 1983 investigation and found to be statistically accurate.

A probe was used to separate the grains and to better identify charcoal and composite grains. A magnetic rod pen was used to discriminate dark grains of hematite and magnetite from charcoal.

SEDIMENTARY STRUCTURE

To study a cross-section of beach, it was necessary to dig a trench perpendicular to the shore down to the approximate water level. The sides were than smoothed to allow for structure identification. Because we had not anticipated this study method ahead of time, no provisions were made for collecting a peel of the cross-sections. In each case, a visual observation was made and photos were taken of significant structures observed. A sketch was also made of each cross-section with particular attention to visible structures. Sand samples were taken of distinctive layers for further analysis. Some samples were analysed for grain size, while others were checked for organic content.

Samples checked for organic content used a one gram sample heated until glowing and red hot over a bunsen burner. This took approximately 10 minutes. The sample was then allowed to cool for 30 minutes and reweighed.

$$\text{percent of nonorganic matter} = \frac{\text{weight of heated sand}}{\text{weight of unheated sand}} \times 100$$

RESULTS

GRAIN SIZE

Table 2-1 indicates the mean phi size for the years from 1982-1986 and 1992 while Table 2-2 shows the mean phi sizes for this year only. A comparison of these results shows that every site has shown a decrease in grain size since 1986. Some showed significantly smaller grains although all still showed in the fine grain size range. Four of the beaches sampled went from medium grain size to fine. The average grain size in 1986 was 2.15 while the average for 1992 is 2.46. Figures 2-1 A thru I show the mean phi sizes for each site for every year investigated.

SHAPE AND COMPOSITION

Table 2-3 shows the shape and composition of beaches in this study. Though the same beaches were not used in the original study in 1983, the result of both show little change in shape or composition. Table 2-4 shows a comparison of the results of each study. Figures 2-2 A & B show the percentages for 1983 vs. 1992.

In the original study, six sites were sampled at Nautiloid Canyon; however, only two sites were used for this year's investigation. There were no significant differences except that the percentage of charcoal in 1983 was 6+%, whereas in 1992 it has apparently been reduced to only 2%. If all six sites had been tested, perhaps a higher percentage of charcoal would have been found.

SEDIMENTARY STRUCTURE

Of the four beaches on which cross-sections were completed, two will be discussed in some detail. The analysis of North Canyon indicated that the structures present represented a separation bar with back eddy flow resulting from recirculating currents. The presence of organic material mixed with fine red clay deposits suggested a flood within the main river channel. These deposits were found approximated 25 cm. below the surface. Similar new deposits were noted on several beaches down river after heavy rains during our 11 days on the river.

Figure 2-3 shows the structure of the cross-section. To check the organic bed angle another trench was dug perpendicular to the first, where the organic material was the thickest, and parallel to the shoreline. A dip angle of 9 to 10 degrees was determined, strengthening our interpretation of a recirculation current. This layer proved to contain approximately 4% organic material. The presence of finer sediment phi sizes which usually stay in suspension, settled out as a result of the quiet water formed by the back eddy.

The sedimentary structures found on Awatubi and Nevills showed a similar pattern. However, the base material of each trench was coarse gravels with a wide range of sizes.

The last of the four beaches trenched, Grapevine, showed four distinct layers of crossbedding. The crossbedding, as shown in Figure 2-4, began at a depth of approximately 24 cm. and was a result of dune formation within the river current. Each bed was approximately 5 to 6 cm. in depth. An analysis of the samples collected showed an average phi size of 1.96. The sediments above and below the crossbedded layers showed uniform layers of relatively undisturbed sand. Table 2-5 shows the results of all phi analysis.

CONCLUSIONS AND RECOMMENDATIONS

GRAIN SIZE

The grain size since the 1986 study has changed an average of almost one phi size. This is a significant change in grain size and is a strong indicator that further studies should be made. One possible cause of the decrease in grain size could be the increased amount of vegetation on many of the beaches investigated. One beach in particular, Grapevine (L-81.3) showed little vegetation and much less overall change in grain

Table 2-1 Mean Phi Size on Selected Beaches

RIVER MILE	BEACH	SAMPLE SITE	1982	1983	1984	1985	1986	1992
8	BADGER CREEK	T-3	1.97	2.2	2.11	1.94	1.91	2.1
	BADGER CREEK	T-27	1.75	1.66		1.63	1.84	2.18
34.7	NAUTILOID	T-12		2.13	2.12	2.11	1.93	2.65
	NAUTILOID	T-14		2.06				2.66
53	NANKOWEAP	T-10		2.1				2.59
	NANKOWEAP	T-30	2.33	1.75	2.21	1.96	2.35	2.5
61.5	LITTLE COLORADO RIVER	RANDOM		2.53				2.41
75.5	NEVILLS	T-6	2.13		2.63	1.94	1.8	2.47
81.3	GRAPEVINE	T-15						1.79
	GRAPEVINE	T-30		1.61	1.8		1.57	2.05
93.7	GRANITE RAPID	T-6						3.03
108.3	BASS CAMP	T-4	2.54		2.56	2.17	2.6	2.8
	BASS CAMP	T-19		2.53				2.75
136.4	PONCHO'S KITCHEN	T-5		2				2.31
	PONCHO'S KITCHEN	T-34		1.88				2.76
166.6	NATIONAL CANYON	T-4						2.78
	NATIONAL CANYON	T-38	2.58	2.69	2.2	2.2	2.43	2.57
220	MILE 220	T-10						2.46
	MILE 220	T-20		2.57	2.45	2.32	2.17	2.47

Table 2-2 Mean Phi Sizes for 1992 Samples

MILE	REFERENCE AREA AND SAMPLES	MEAN PHI SIZE	WENTWORTH SCALE CLASSIFICATION
8	BADGER CREED T-3	2.1	FINE SAND
	BADGER CREEK T-27	2.18	FINE SAND
34.7	NAUTILOID CANYON T-12	2.65	FINE SAND
	NAUTILOID CANYON T-14	2.66	FINE SAND
53	NANKOWEAP T-10	2.59	FINE SAND
	NANKOWEAP T-20	2.5	FINE SAND
61.5	LITTLE COLORADO RIVER RANDOM	2.41	FINE SAND
75.5	NEVILLS T-6	2.47	FINE SAND
81.3	GRAPEVINE T-15	1.79	MEDIUM SAND
	GRAPEVINE T-30	2.05	FINE SAND
93.7	GRANITE RAPID T-6	3.03	VERY FINE SAND
108.3	BASS CAMP T-4	2.8	FINE SAND
	BASS CAMP T-19	2.75	FINE SAND
136.4	PONCHO'S KITCHEN T-5	2.31	FINE SAND
	PONCHO'S KITCHEN T-34	2.76	FINE SAND
166.6	NATIONAL CANYON T-4	2.78	FINE SAND
	NATIONAL CANYON T-38	2.57	FINE SAND
220	MILE 220 T-10	2.47	FINE SAND
	MILE 220 T-20	2.46	FINE SAND

Table 2-3 Shape and Composition 83-92 Comparison

SHAPE	PERCENT 1983	PERCENT 1992
ANGULAR	14	16
SUB-ANGULAR	54	47
SUB-ROUND	29	31
ROUND	3	6

COMPOSITION	PERCENT 1983	PERCENT 1992
COMPOSITE GRAINS	6	2
QUARTZ	88	84
MISCELLANEOUS	6	13
CHARCOAL	1	1

Table 2-4 Percent Grain Shape and Composition

BEACHES	ANG	SUB-ANG	SUB-RD	RD	CG	Q	MO	MISC	C
BADGER CREEK T 3	16	48	30	6	2	76	12	8	2
BADGER T 27	12	52	30	6		96		4	
BADGER AVERAGE	14	50	30	6	1	86	6	6	1
NAUTILOID T 12	16	58	22	4		88	2	10	
NAUTILOID T 14	20	58	20	2	2	84	2	8	4
NAUTILOID AVERAGE	18	58	21	3	1	84	2	9	2
NANKOWEAP T 10	16	40	34	10		90	6	4	
NANKOWEAP T 30	6	60	32	2		90	6	4	
NANKOWEAP AVERAGE	11	50	33	6		90	6	4	
LITTLE COLORADA RIVER	16	52	28	4		88	6	6	
NEVILLS T 6	14	30	48	8		92	2	6	
GRAPEVINE T 15	24	48	24	4		90	6	4	
GRAPEVINE T 30	14	46	38	2		76	10	14	
GRAPEVINE AVERAGE	19	47	31	3		83	8	9	
GRANITE RAPID T 15	20	42	30	8	6	72	12	10	
BASS CAMP T 4	18	42	28	12		80	12	4	4
BASS CAMP T 19	8	56	30	6	2	86	2	8	2
BASS CAMP AVERAGE	13	49	29	9	1	83	7	6	3
PONCHO'S KITCHEN T 5	16	48	32	4		88	2	10	
PONCHO'S KITCHEN T 34	20	38	32	10	12	84	2	2	
PONCHO'S KIT. AVERAGE	18	43	32	7	6	86	2	6	
NATIONAL T 4	20	40	36	4		76	10	12	2
NATIONAL T 38	14	46	32	8		82	6	10	2
NATIONAL AVERAGE	17	43	34	6		79	8	11	2
MILE 220 T 10	14	54	26	6	2	84	8	6	
MILE 220 T 20	14	52	28	6	2	82	6	10	
MILE 220 AVERAGE	14	53	27	6	2	83	7	8	

TABLE 2-5 TRENCH ANALYSIS PHI SIZE

MILE NUMBER	REFERENCE AREA	MEAN PHI SIZE	WENTWORTH SCALE CLASSIF.
20.5	MILE 19 ORGANIC LAYER	3.46	VERY FINE SAND
	MILE 19 DRK. BRN. SED.	3.65	VERY FINE SAND
	MILE 19 OXIDIZED CLAY	3.69	VERY FINE SAND
	MILE 19 LT.BRN. SED.	2.72	FINE SAND
58	AWATUBI SURFACE SAND	2.4	FINE SAND
	AWATUBI ABOVE GRAVEL	2.16	FINE SAND
	AWATUBI GRAVEL BOTTOM		GRAVELS
75.5	NEVILLS WHITE SAND	2.47	FINE SAND
	NEVILLS DRK. MIDDLE SED.	3.17	VERY FINE SAND
	NEVILLS SAND AND GRAVEL		
81.3	GRAPEVINE CROSSBED #1	2.25	FINE SAND
	GRAPEVINE CROSSBED #2	1.88	MEDIUM SAND
	GRAPEVINE CROSSBED #3	2.01	FINE SAND
	GRAPEVINE CROSSBED #4	1.98	MEDIUM SAND
	GRAPEVINE TOP SAND LAYER	1.98	MEDIUM SAND
	GRAPEVINE 2ND LAYER	2.08	FINE SAND

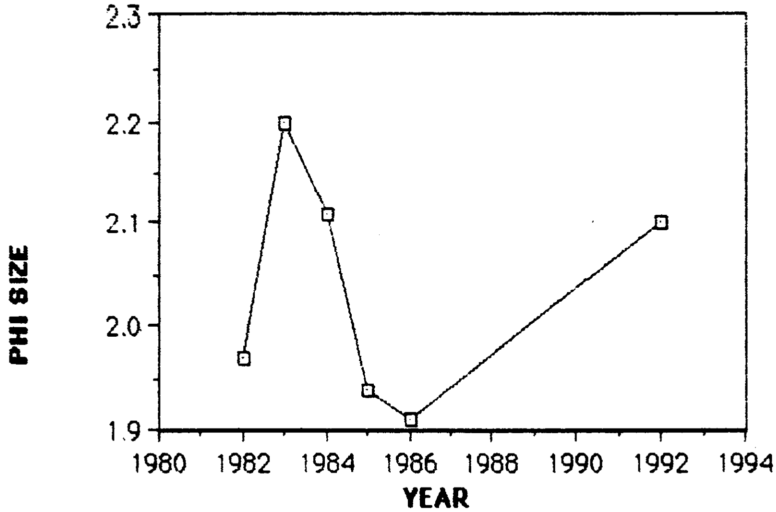


FIG. 2-1 A BADGER CREEK T-3 PHI SIZE COMPARISON

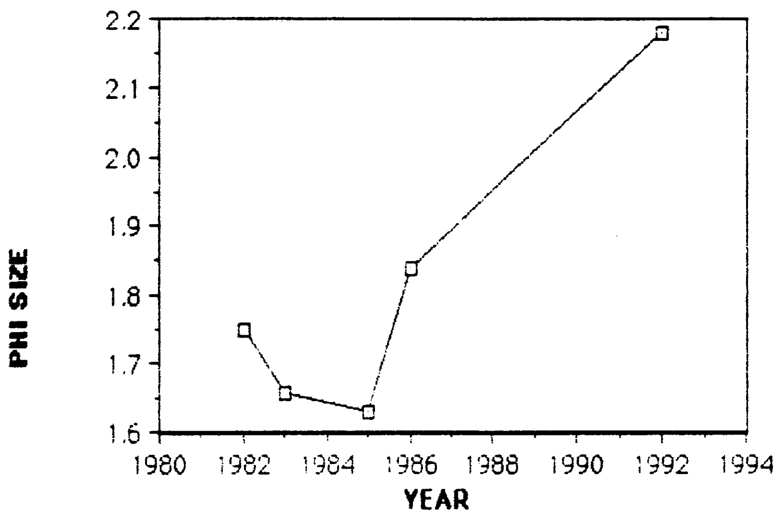


FIG.2-1 B BADGER CREEK T-27 PHI SIZE COMPARISON

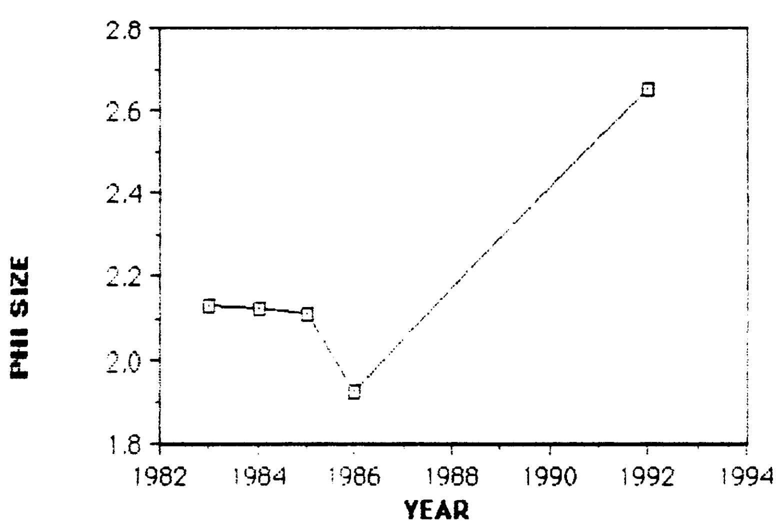


FIG. 2-1 C NAUTILOID T-12 PHI SIZE COMPARISON

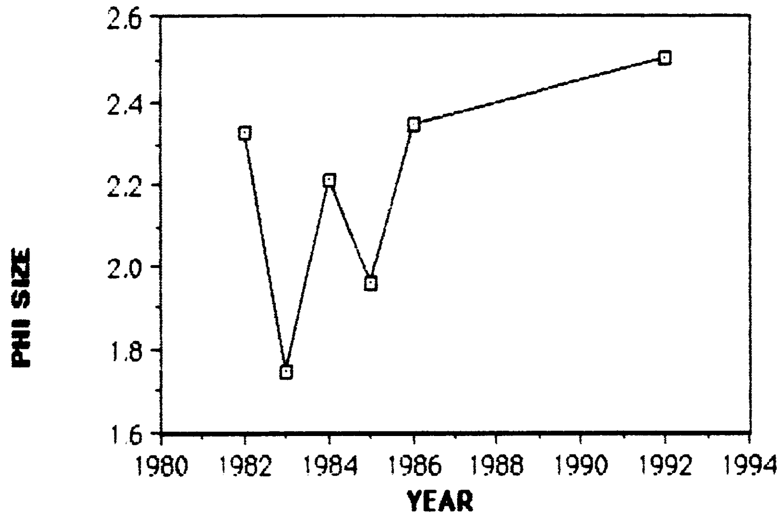


FIG.2-1 D NANKOWEAP T-30 PHI SIZE COMPARISON

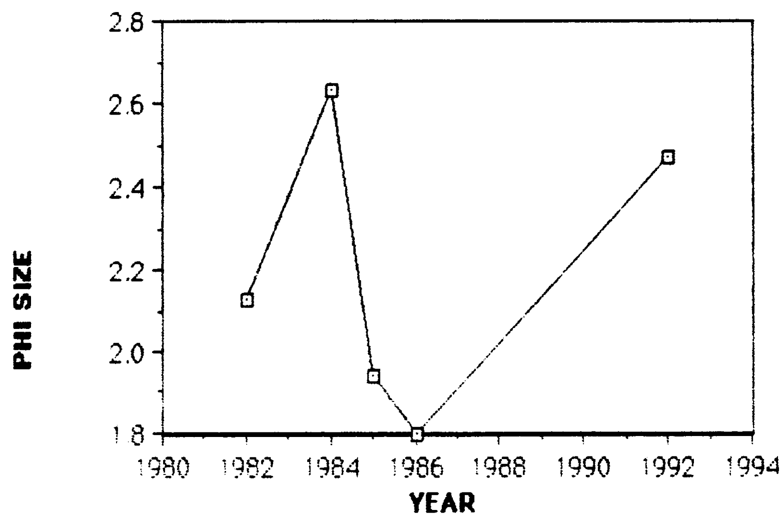


FIG. 2-1 E NEVILLS T-6 PHI SIZE COMPARISON

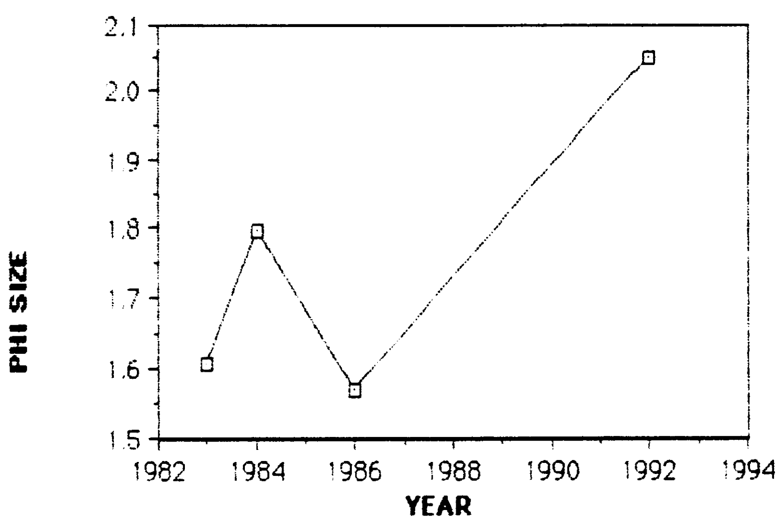


FIG. 2-1 F GRAPEVINE T-30 PHI SIZE COMPARISON

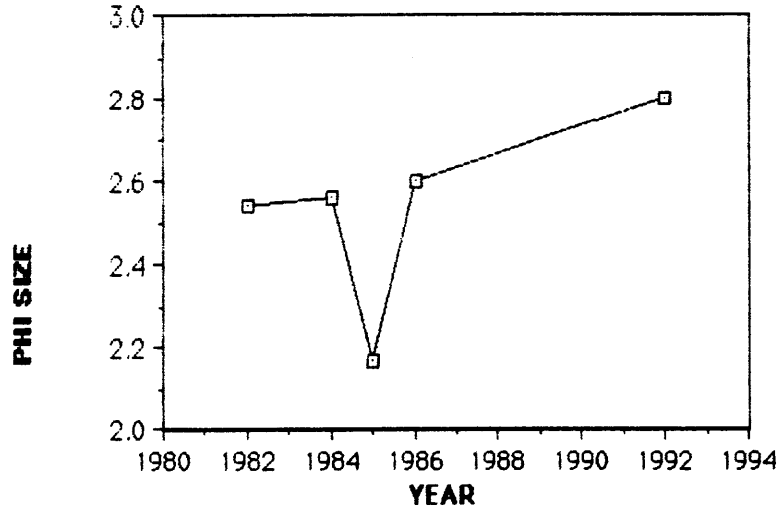


FIG. 2-1 G BASS CAMP T-4 PHI SIZE COMPARISON

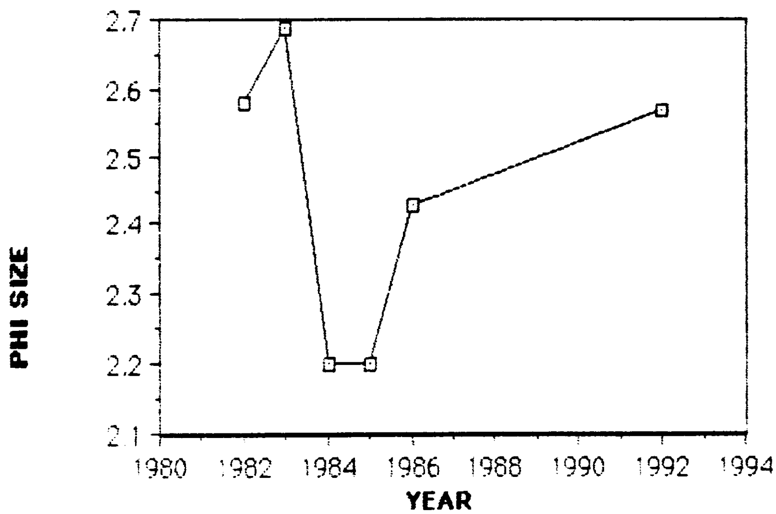


FIG. 2-1 H NATIONAL CANYON T-38 PHI SIZE COMPARISON

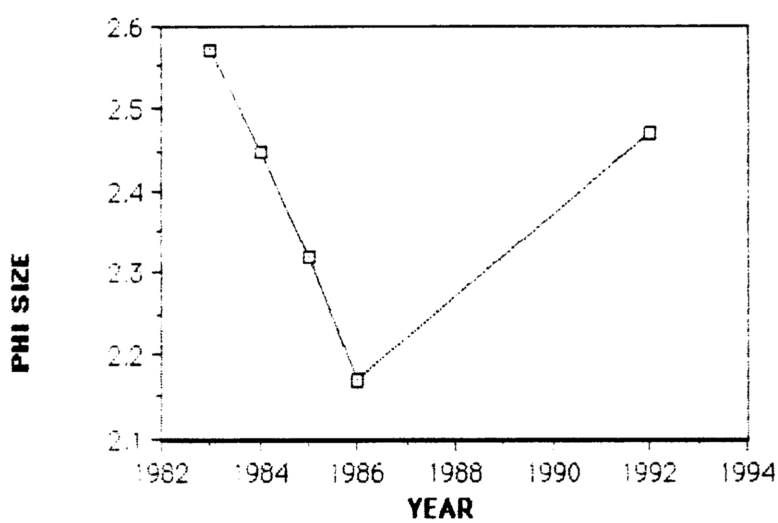


FIG. 2-1 I MILE 220 T-20 PHI SIZE COMPARISON

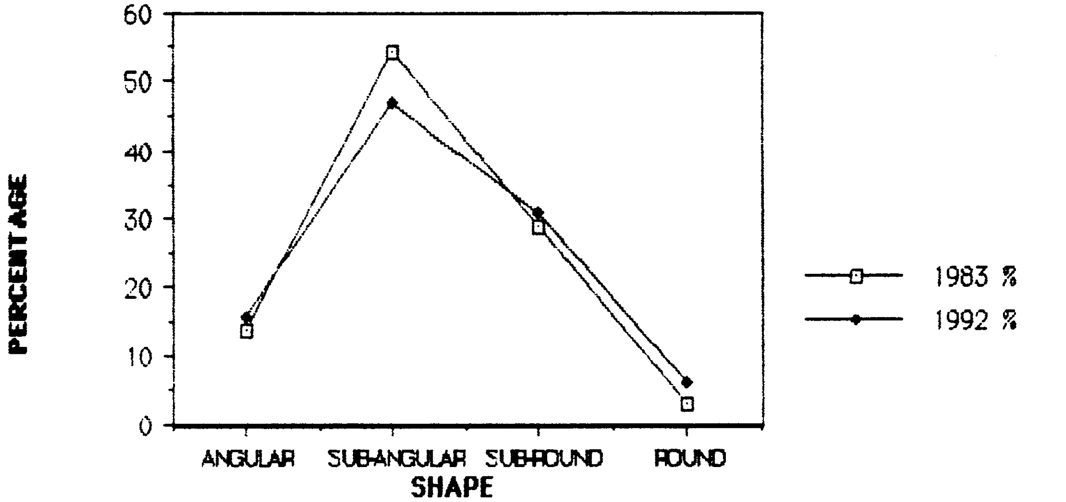


FIG. 2-2 A SHAPE PERCENTAGE COMPARISON
1983 VS. 1992

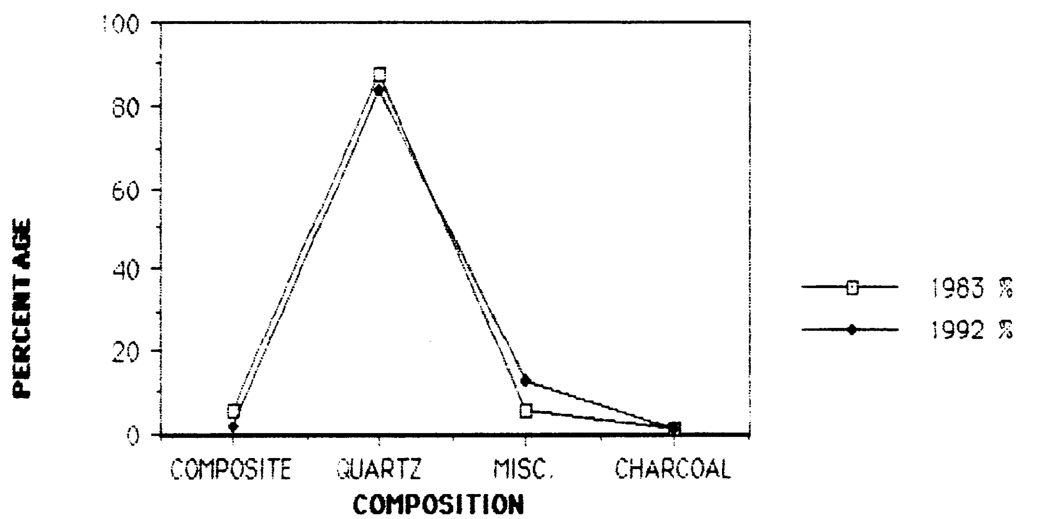
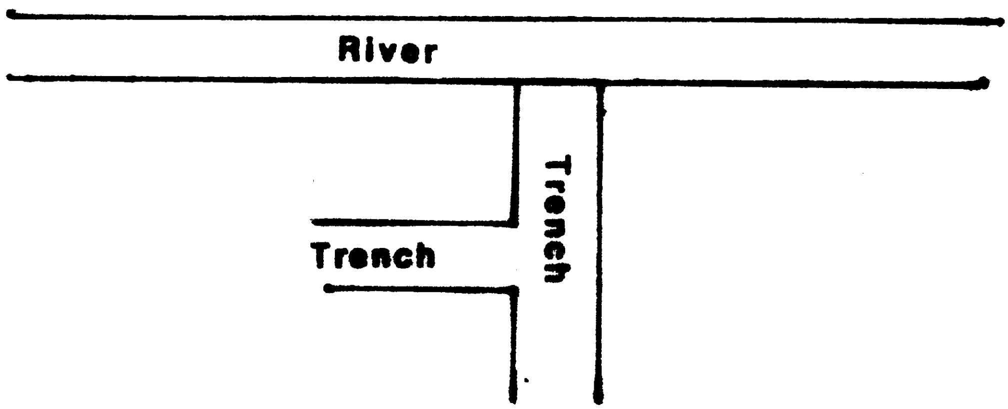


FIG. 2-2 B COMPOSITION PERCENTAGE
COMPARISON 1983 VS 1992

FIGURE 2-3 TRENCH CROSS-SECTION MILE 19



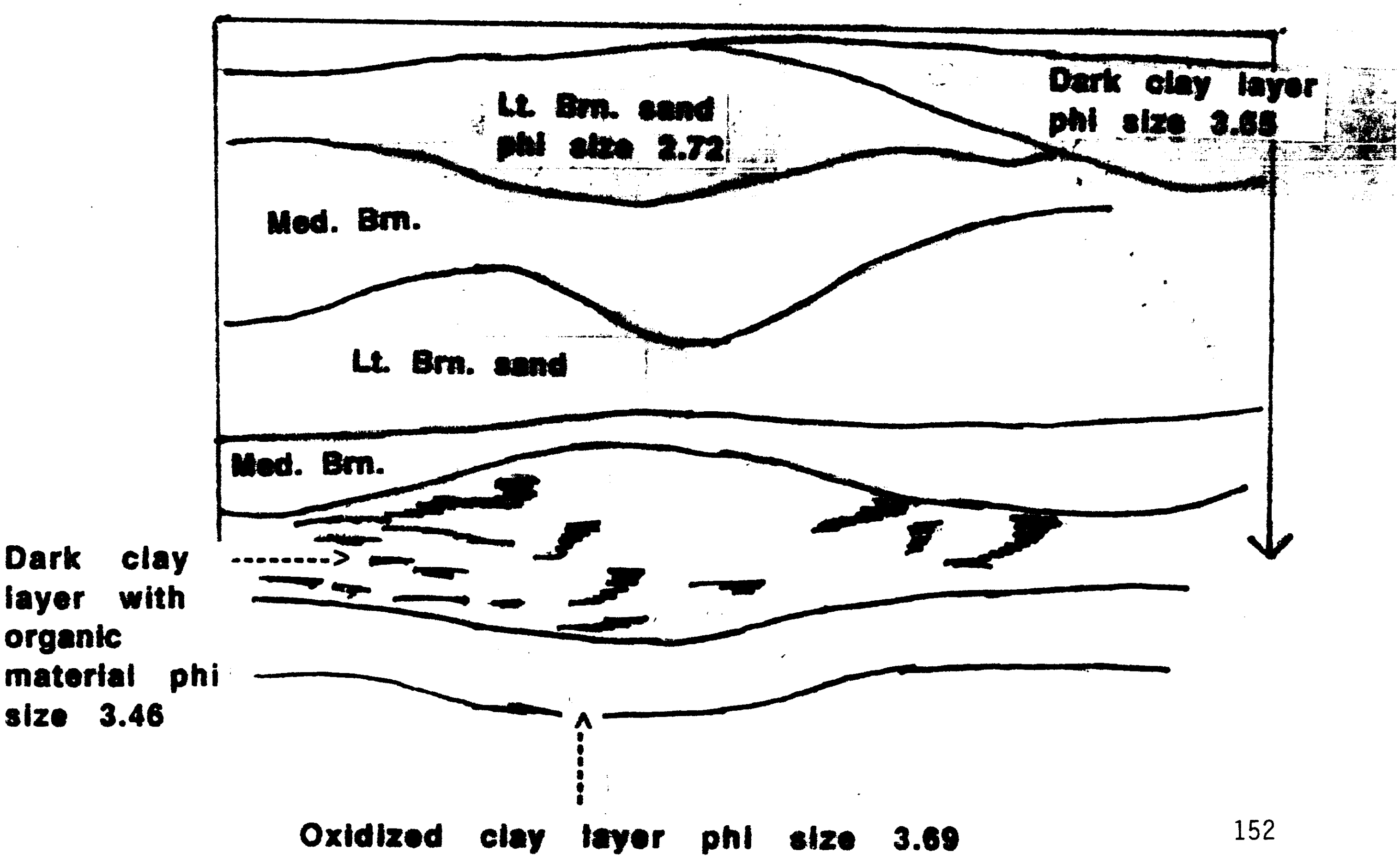
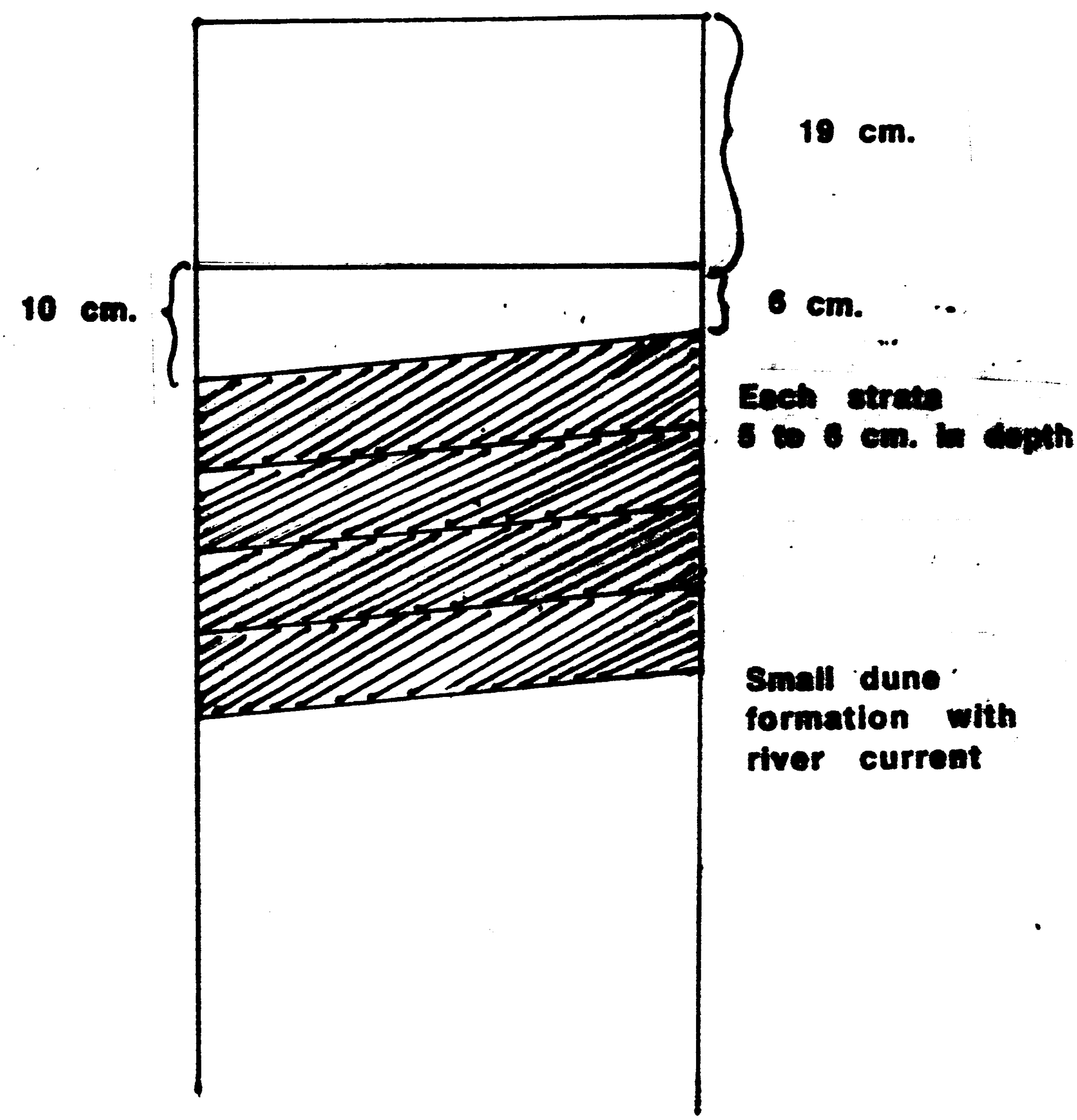


FIGURE 2-4 TRENCH CROSS-SECTION MILE 81.3



phi size. If the current trends continue, beach erosion could be significantly increased if the flow rates of the Colorado River were to increase.

A question for future study could be the correlation between grain size and amount of beach vegetation.

SHAPE AND COMPOSITION

There has been no significant change in the shape or composition of the sand grains along the Colorado River corridor over the last nine years.

SEDIMENTARY STRUCTURE

Based on the four beaches studied, and the results of other investigations, the major depositional processes along the Colorado River corridor appear to be due to current recirculation and eddy formation.

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Chapter 12

Trace Fossils

Christine Donovan, Kelcy Thompson, William West

Introduction

Trace fossils are the imprints left by early organisms as they went about their day-to-day activities. Originally these traces were made in different types of loose, fine-grained sand or mud, and are now found in specific formations of sedimentary rock. They differ from body fossils in that they are not the preserved hard parts of the animal itself, but rather a record of the animal's activity at a certain point in its life span.

A wide variety of trace fossils are found in abundance in the Early Paleozoic layers of the Grand Canyon, specifically in the Early and Middle Cambrian Tapeats Sandstone, Bright Angel Shale and Muav Limestone formations (Middleton & Elliott, 1990), which were examined for this study. Another unit represented in this study is the mid-Permian Coconino Sandstone at Badger Creek. Since no hard body fossils have been found in this formation, the use of trace fossils are one of the few ways paleontologists have of making environmental inferences occuring during this period (Middleton, Elliott & Morales,1990).

Locating and studying trace fossils aids scientific investigation into the existing depositional environment of the area at the time the organisms were alive. Paleontologists studying the traces can make inferences into what type of environment and processes were at work during the lifespans of the organisms responsible for making the trace fossils. Their importance becomes even greater when it is noted that few hard body fossils were preserved in those time periods, making trace fossils unique eyes into the past.

The trace fossil team consisted of two high school science teachers and a graduate geology student. Their job was to collect as varied an assortment of specimens as possible. Upon analyzing the specimens in the lab, the team was to report on what type of environment and processes were present when the organisms flourished.

Methods

The trace fossil team collected specimens at the following three pre-determined sites rich in fossils, which were logged into the daily schedule of stops: mile L-8, Jackass Creek; mile R-61.8, LCR Confluence and mile R-120, Blacktail Canyon. At each stop, the researchers moved through the fossil beds placing red flaggings on specimens that were to be studied. Rock pieces on/in the talus slope, or easily broken from ledges, were marked with their location and placed in a collection sack. A data collection sheet was

TRACE FOSSIL DATA COLLECTION SHEET

SITE:____________________APPROXIMATE LOCATION:______________ FORMATION

NAME:_______________

ROCK DESCRIPTION: Color (fresh and weathered)______________________________

Grain size, sorting, and shape______________________________

Induration and cement type______________________________

Structures present____________________________________

Bedding thickness____________________________________

FOSSIL TYPE: Trace (resting, crawling, grazing, feeding, dwelling, escape) Trackway Body Fossil

DESCRIPTION: Original orientation: vertical horizontal inclined

Position: bedding plane vertical section inclined section

Morphology: linear straight curved spiral ridged(grooved) meandering

zigzag bilobed circular elliptical star spherical

hemispherical conical cylindrical branching U-shaped

other

Measurement: width (diameter)___________________________

height (thickness)__________________________

length_________________________________

other_________________________________

diameter: constant_________or varied___________

Surface: smooth annulated segmented striated ridged(grooved)

pelleted irregular scratchmarked

Branching: constant angle?________constant diameter?_________

Inner sediment: finer same coarser structureless laminated

Sketch:

Figure 1. Data collection sheet for trace fossils in the Grand Canyon

Figure 2

TRACE FOSSIL FIELD CHECK LIST

The following field check list for trace fossils has been provided by Stephen Albert (UCLA). The check list is intended primarily for field geologists and paleontologists (rather than ichnologists) who come across trace fossils in the field. The list points out the need to gather basic information on trace structure. Steve would appreciate hearing from those of you having suggestions for the improvement of this check list.

1. Age: ______________ Formation: ______________ Region: ______________
2. Type of Trace Fossil: burrow ____, track ____, trail ____, boring ____.
3. Rock Type: _________, Color of Matrix: ___________, Color of Fossil ________
4. Original Orientation of Trace Fossil: vertical ____, horizontal ____, inclined ____
5. Fossil is visible: on bedding plane ____ (upper ___, lower ___), in vertical section ____, in inclined section ____.
6. Morphology: linear ____, straight ____, curved ____, spiral ____, ridge ____, meandering ____, zig-zag ____, groove ____, bilobed ____, circular ____ elliptical ____, star-shaped ____, spherical ____, hemispherical ____, conical ____ cylindrical ____, wall-like ____, U-shaped ____, branched ____.
7. Measurements (give range): width or diameter: ______________________
   height or thickness: __________________, length ______________________,
   other ____;
   Diameter of specimen constant ____, varies ____, Density in/on rock __________
   ____.
8. Surface of trace fossil (or wall of burrow): smooth ____, annulated ____, segmented ____, pellets ____, striated ____, ridges and/or grooves ____, scratchmarks ____, irregular ____, other ______________________________.
9. Branching: yes ____, no ____, possibly ____. Is branching at constant angle? ____
   Does diameter remain constant? ____; Type of branching: dichotomous ____, monopodial ____, feather-stitch ____, irregular ____, other ______________
10. Sediment in burrow: finer ____, same as ____ coarser ____ than matrix; structureless ____, laminated or backfilled ____, other ________________.
    Evidence of systematic displacement or repitition of burrow? ________________
    ____
11. Sketch of trace fossil:

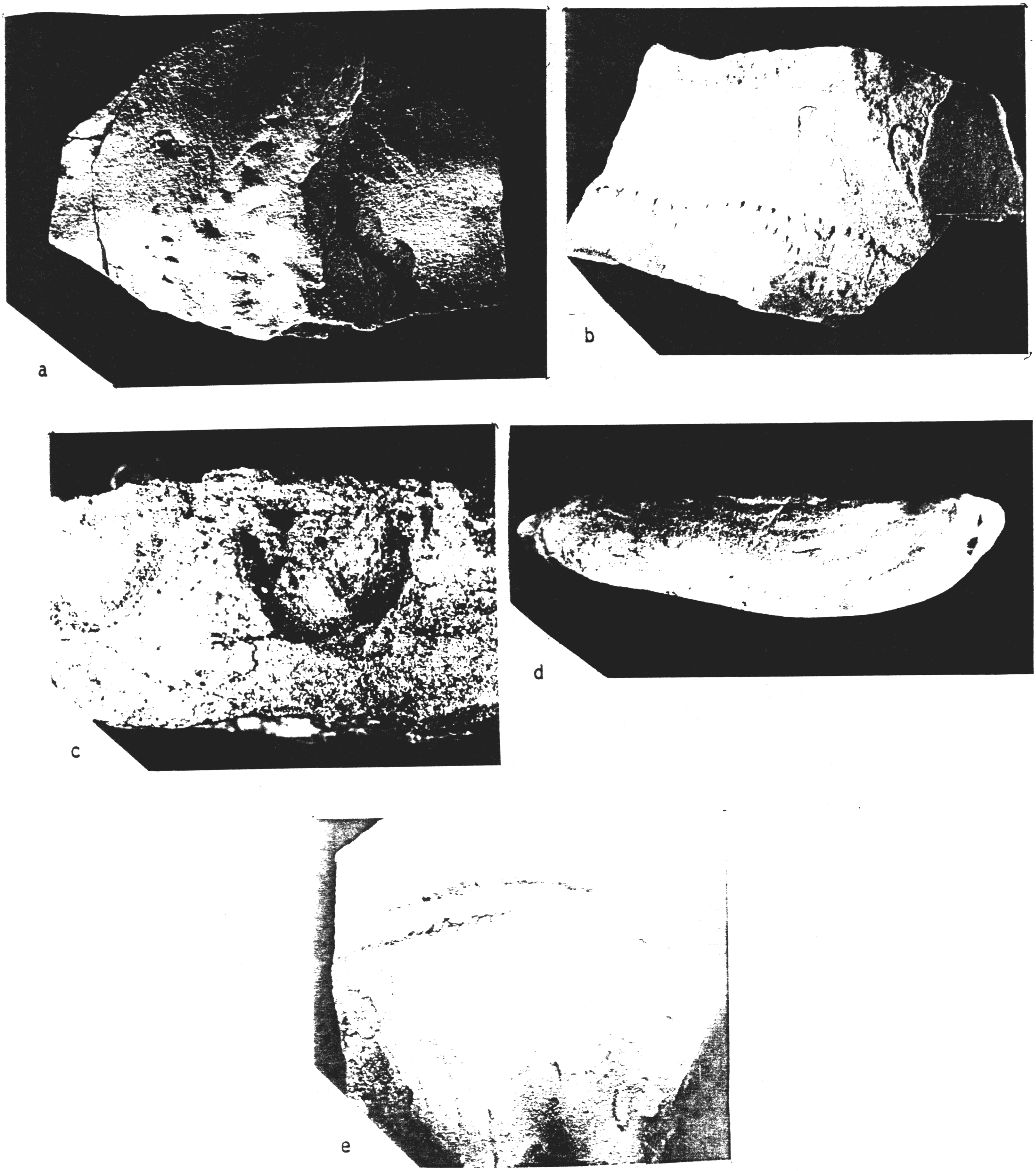

Figure 3. Trace fossils from sand lens in the Bright Angel Shale at Blacktail Canyon in the Grand Canyon. a) *Diplichnites sp.*; b) *Diplichnites sp.*; c) *Diplocraterion sp.*; d) *Teichichnus sp.* e) un-named trackway.

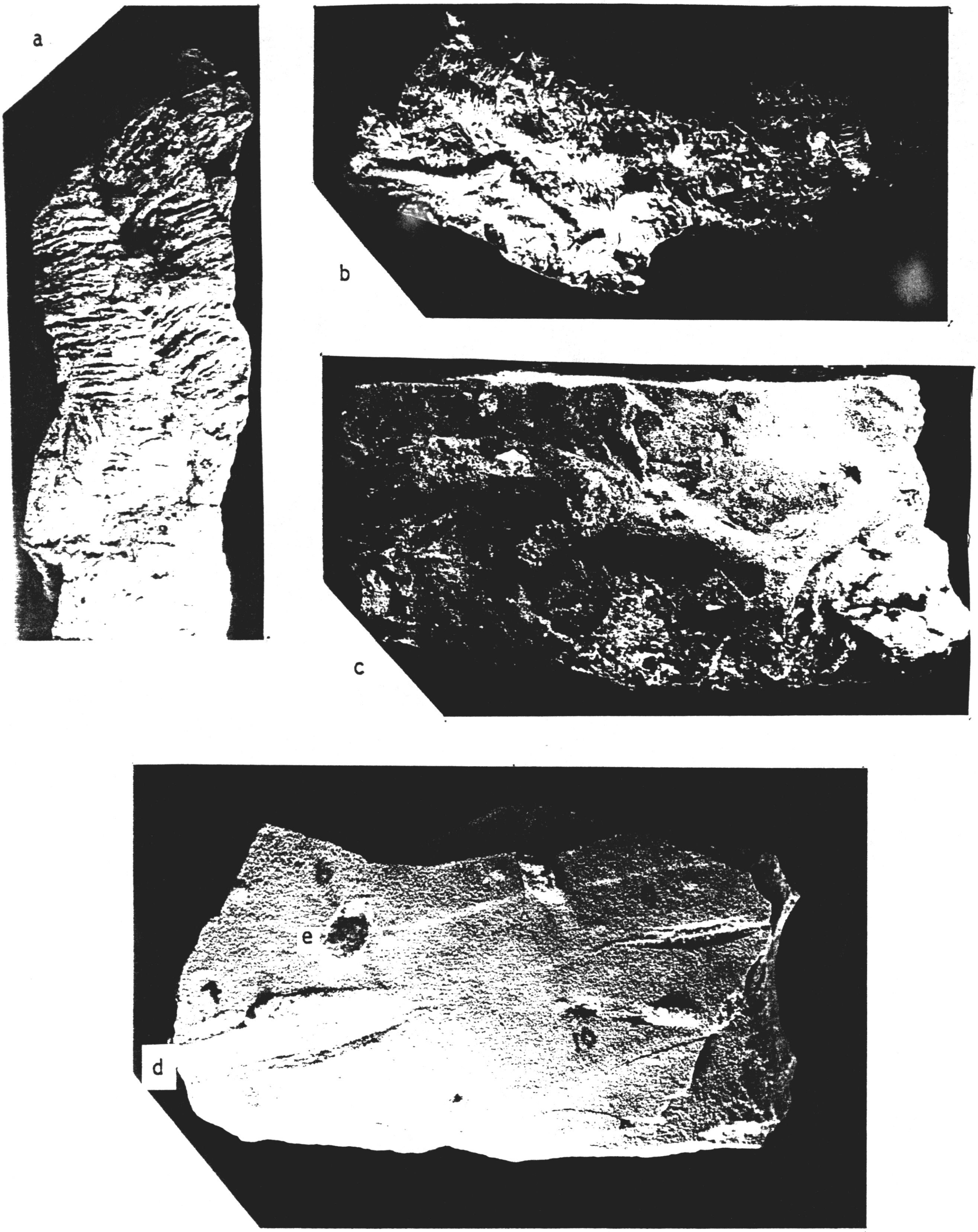

Figure 4. Trace fossils found in the transition zone, Bright Angel Shale and Tapeats Sandstone at R61.8 in the Grand Canyon. (a,b,c) Trace fossils found in the Coconino Sandstone at L Jackass Creek in the Grand Canyon. (d,e)
a) *Cruziana sp.*; b) *Cruziana* and *Rusophycus sp.*; c) un-named burrow; d) *Onisconidichnus sp.?*; e) un-named track

TABLE 12-1. Trace Fossil Description

SPECIMEN NUMBER	SITE	FORMATION	LOCATION	FOSSIL DESCRIPTION	SURFACE	POSSIBLE TAXONOMY
1	L Jackass Creek	Kaibab Limestone	talus slope	linear feeding/dwelling burrow	irregular	
2		Coconino Sandstone	talus slope	straight crawling trace	segmented	*Scolecoprus sp.*
3			talus slope	straight crawling trail	ridged	
4			talus slope	curved, ridged crawling trail	smooth	
5			talus slope	straight-curved crawling trail	smooth, secondarily ridged	
6			talus slope	three-clawed single track	irregular	
7			talus slope	linear crawling trails (3)*	ridged/grooved	*Onisconidichnus sp.*
8			talus slope	curved crawling trace	ridged, segmented	*Scoleocoprus sp.*
9	R 61.8	transition zone, Bright Angel Shale-Tapeats Sandstone	talus slope	curved crawling traces (4)*	striated	*Cruziana sp.*
10			talus slope	branched feeding/dwelling burrow	smooth	
11			talus slope	stacked horizontal dwelling/feeding burrow	smooth	*Teichichnus sp.*
12			talus slope	vertical dwelling burrows (2)*	dimpled (top view only)	*Diplocraterion sp.*
13			talus slope	curved crawling trace	smooth	*Diplichnites sp.*
14a			bedding plane	bilobed resting traces (3)*	striated	*Rusophycus sp.*
14b				curved sinuous horizontal burrows (3)*	smooth	*Paleophycus sp.*
14c				horizontal, U-shaped feeding traces (2)*	smooth	
15	Blacktail Canyon	sand lens, Bright Angel Shale	talus slope	stacked, horizontal dwelling /feeding burrows (3)*	smooth	*Teichichnus sp.*
16			talus slope	straight-curved trackways (3)*	scratchmarked	*Diplichnites sp.*
17			bedding plane	U-shaped vertical dwelling burrow	smooth	*Diplocraterion sp.*
18			talus slope	curved trackway	scratchmarked	

*denotes number of specimens collected

Table 12-2

Fossil Rock Descriptions

(Specimens from Table 11-1)

LOCATION	SPECIMEN	COLOR*	GRAIN SIZE SORTING,SHAPE	INDURATION CEMENT TYPE	STRUCTURES PRESENT	BEDDING THICKNESS
Jackass Creek	3	F-white W-light brown	fU to fL, well sorted, well rounded	well indurated, silica	up to 10 mm planar laminated	n/a
	5	W-tan	mL, fine sorted, rounded	well indurated, silica	fine, planar laminated bedding	rock fall n/a
LCR Confluence	9	F-grey-green W-dark tan	vfU, very well sorted, very well rounded	well indurated, silica	massive	n/a
	11	F-light tan W-dark tan	fU, fine sorted, well rounded	weak to medium induration, silica	massive	n/a
	12	F-light grey W-blackish brown	fU to vfU, well sorted, very well rounded	well indurated, silica	massive	n/a
Blacktail Canyon	18	F- brownish-tan W- same	mU to mL, well sorted, sub rounded	well indurated, silica	planar laminated	11.25cm by 22.5 cm
	19	F- brown W-same	vfU, very well sorted, well rounded	well indurated, silica	massive	n/a

*F-fresh, W-weathered

used by the team for recording site information (Figure 1); this sheet was one which was modified from an original form furnished by Dr. Beus (Figure 2). When the fossil bearing rock could not be removed, pictures were taken in situ and the data collection sheet was completed at the site.

Specimens brought back to the lab were photographed. Data collection sheets were paired with the corresponding fossil, and specimen numbers were assigned. The following references were used for identification of the specimens: Beus and Morales (1990), Martin (1985), and Teichert (1975).

Discussion

The Coconino Sandstone was formed as eolian deposits (Middleton et al., 1990). Our research noted that the sand grains in all specimens collected at the Jackass Canyon (Badger Creek) site are composed of fine grained, rounded sand particles which are silica cemented (Table 12-2), which is characteristic of eolian depositional processes. Traces from this location in the canyon suggest a dry depositional environment, with possible intermittent wetting (McKee,1945). Ichnology has classified the organisms that lived at this time as small vertebrates and invertebrates (Beus,1990). Figure 4-e appears to be a single, three clawed track, possibly moving uphill as evidenced by the sand bulge at the rear of the imprint. Several other crawlings (Figure 4-d) were also identified in this sandy environment.

Trace fossils were found in great numbers by the team in the transitional zone of the Bright Angel Shale and Tapeats Sandstone (Table 12-1). Grain size varied from very fine to medium sand which was well indurated (Table 12-2). Burrows, crawlings and resting traces measured by the research team were found in massive, well-indurated, silica-cemented rock. Several of the traces were produced by organisms previously identified as suspension feeders and detritus-ingesting annelids (figure 3-c,d & 4-a,b,c)(Middleton & Elliott,1990). The above evidence suggests the traces were formed in a marine, near shore, shelf building depositional environment.

The trace fossil team observed, but did not document, many burrows and crawlings on the underside of bedding layers in the Bright Angel Shale. Sites such as Matkatamiba Canyon and Deer Creek, where many visitors congregate, were not conducive to the collecting of specimens. Layers here were not well indurated, and were composed of very fine sediment which was crumbly and easily eroded. These mudstones and micaceous shales suggest a depositional environment representative of mud and sand suspension settlings in a disturbed sub-tidal area (Martin, 1985).

Conclusion

From this research it is evident that trace fossils are abundantly preserved in the Tapeats Sandstone, Bright Angel Shale and the Coconino Sandstone. The activities of the organisms enables researchers to reconstruct the historical and regional conditions present during the early Paleozoic Era. The depositional environments of these layers are diverse and range from sandy, eolian settings to shallow marine conditions.

It is suggested that these locations, rich in trace fossils, be made known to the visitors of the Grand Canyon corridor so they may observe and appreciate its history. Emphasis should be placed on the preservation of these sites so future travelers may enjoy them equally.

References

Beus, Stanley S. and Morales, Michael (eds.),.1990. Grand Canyon Geology. Museum of Northern Arizona Press, Flagstaff, Arizona.

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Chapter 13

Photographic Record of the Colorado River Trip - 1992

Robert L. (Bob) Jones

Introduction

The Photographic Record of this trip, as outlined, was to include pictures of specific beach studies at specific points, and to make a record, in general of the happenings of the trip. Thus, pictures were taken of members of the group at work and at play.

Every beach at which there was a Human Impact Study and/or a Radioactive Study was to be shot in the same way as it had been in past years. At points above the beaches, pictures were to be taken of the entire beach. These vantage points would have to be the same, or very nearly so, as those used in past years. This was done so that comparisons could be made of similar photo-studies of these beaches through the previous successive years of the study. The researcher should be able to tell if there had been any erosional damage, beach build-up, plantlife decline or advancement, and in general how the current year's photographs compared with past years.

The beaches photographed were some at which we stayed for the night, but there were several more that had to be studied. Table 1 is a listing of the beaches under study:

Beach (Mile)	Human Impact Picture	Radioactivity Study Picture	Beach Picture
Badger Creek Rapids (8.0)	x		x
North Canyon (20.5)		x	x
Shinumo Wash (29.2)	x	x	x
Nautiloid Canyon (34.7)	x		x
Nankoweap (53)	x	x	x
Little Colorado River (61.5)		x	
Nevills Rapid (75.5)	x		x
Grapevine Rapids (81.3)	x		x
Phantom Ranch (87.7)		x	

(Beaches under study, continued)

Beach	Human Impact Picture	Radioactivity Study Picture	Beach Picture
Granite Rapids (93.7)	x	x	x
Bass Camp (108.3)	x	x	x
Shiumo Creek (108.6)		x	
Blacktail Canyon (120.2)		x	x
Forster Canyon (122.8)	x	x	x
Deer Creek Falls (136.2)		x	
Poncho's Kitchen (136.4)	x	x	x
Kanab Creek (143.5)		x	
Matkatambia Canyon (147.9)		x	
Havasu Creek (156.8)		x	
National Canyon (166.6)	x	x	x
Lower LavaFalls (179.9)	x		x
(Mile 182.8R)			x
(Mile 193.9R)	x	x	x
(Mile 212.9L)			x
Mile 220 Middle	x	x	x
(Mile 225.0R)			x

Methods

Specifically, photographs were taken as follows:

Type of Study	Picture Taking Sites
Human Impact	At the beginning and end of the transect
Radiation	At or near the sample collecting point
Beach pictures	From previously used vantage points

A necessary requirement in capturing these beach pictures was to take a picture of a chalkboard showing the date, mileage location of the beach from Lee's Ferry, and whether the beach was on the left or right, going down river. In addition, pictures were taken of several other groups conducting their work. Even though pictures were not required of the Beach Profile group, pictures were taken to show their method of conducting their studies. So also were pictures taken of other groups conducting their studies. Pictures were taken of individuals and groups of the Experience members being candidly casual, or at play. Being the chronicler of the trip, I felt it was my job to make a "record" of the trip, and so I did!

The camera used was a Pentax K-1000, which is a particularly rugged little 35 mm camera, and is inexpensive; pictures were shot on T-Max 100 film. The lens was a standard 50 mm Pentax lens. When the light was adequate, a red filter was used to emphasize sky features.

There were many pictures taken of special places along the way, as well as of geological features that were pointed out as being noteworthy. Some beach pictures were taken only from the boat, as it wasn't necessary to stop, but it was necessary to capture a picture. One of the group members held the chalkboard indicating the mile and position of each of these beach locations and the date.

One problem was that the camera had to be available for picture taking at, or near, times when some large rapids would be traversed. The camera got dowsed a couple of times, and had to be given time to dry out. See Recommendations for suggestions as to how to avoid this problem. After the second dowsing the camera was then kept in a zip-lock bag when moving through rapids. Fortunately, it was not necessary to take pictures while actually traversing rapids.

Results

In all, nine (9) 36-picture rolls of film were used to photograph the trip. The film was developed by a professional company, and contact prints have been made for the record. Specific 3.5" x 5" prints were made of the beach pictures, Human Impact Study pictures, and Radiation Study pictures, as requested. Selections of these are in this report.

Recommendations

After learning by experience, some recommendations should be made here:

1. A 35 mm camera with a 50 mm lens seems to be the best and most convenient combination to use.

2. It is suggested that in the future, a 35 mm Nikonos (waterproof) camera be used. A good used model can be purchased for a fair price, and there would be no problem with "surprise" rapids, rain, etc.

3. The photographer should have at his immediate disposal at least two cannisters of 35 mm film each day. These should be in a pocket, or perhaps in one of those small hip packs, in a waterproof container. The film should be removed from the cardboard packaging, but <u>left in the plastic cannister</u> to protect it from water! All other film should be stored in a waterproof ammo can until needed.

4. In changing film in the camera, no matter what kind of camera is used, the photographer should do his/her best to make certain that no sand or water gets inside the camera. One small grain of sand will cause a scratch in the film which could ruin the whole roll.

5. After a complete roll of film is exposed, and removed from the camera, it should be placed in a protective container so that it will not get wet! The best place is back into the plastic container in which it came.

CHAPTER 14: RADIOACTIVITY IN TRIBUTARY SAMPLES

by Neal Ayres and Norm Geiger

I. INTRODUCTION

In the Grand Canyon National Park, sedimentary rocks may have higher-than-normal levels of radioactive uranium since uraniferous breccia pipes are common in this region of Arizona. The level of radioactive uranium tends to increase as the percentage of silica increases in the rock, and tends to be higher in low temperature igneous rocks. The breccia pipes supply a natural uranium source for the Colorado River sediments. An alternative source of uranium could be man-made contamination, through surface spill, mining activity, or other surface disruptive activity of the natural uranium ores.

To monitor the possibility of contamination, research continued for the fourth year to determine the levels of radioactive uranium in the Colorado River system within the Grand Canyon National Park. Since radioactive isotopes precipitate out of water, mud deposits were collected as samples. The data gathered from these samples will be used to compare with 1989, 1990 and 1991 data as well as future comparisons.

Hypothesis: The levels of radioactive uranium in the Colorado River sediments are within a normal range as expected for sediments sourced from locally uraniferous sediment rocks and low temperature igneous rocks.

Objectives:

1) To resample 1989, 1990 and 1991 sites near stream tributaries and to establish new sites in the Colorado River of the Grand Canyon

2) To analyze sediment samples and measure the concentration of radioactive uranium

II. METHODS

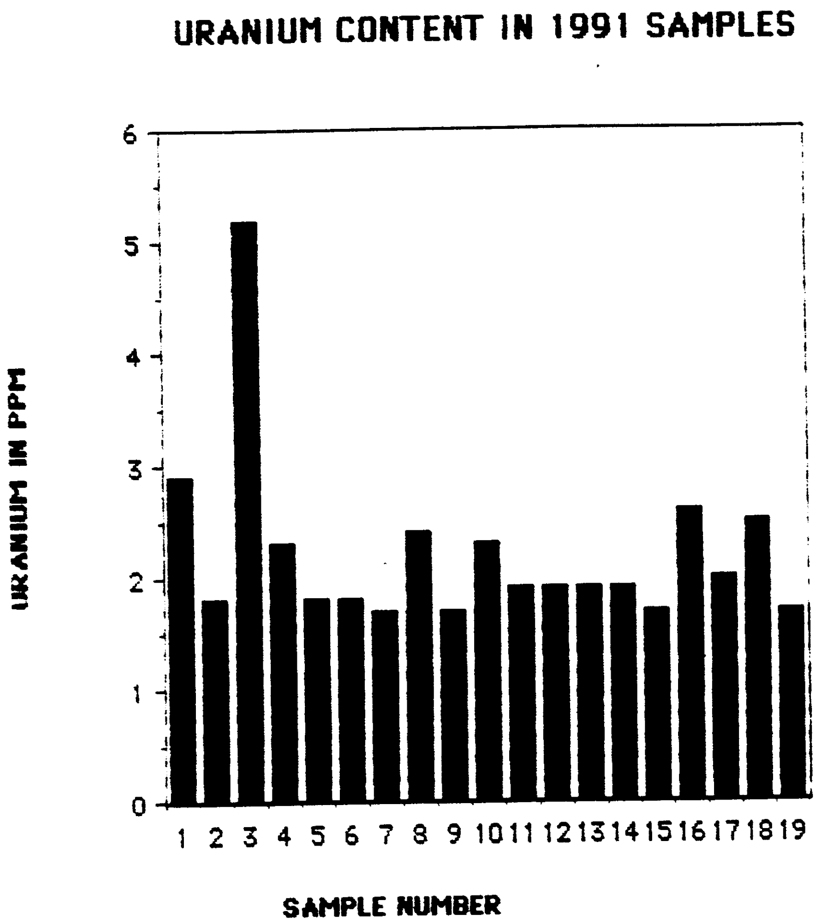
A) Study Site: The 1992 sample area on the Colorado River was between North Canyon (mile 20.6) and 220 Mile Canyon. Approximately one kilogram of the finest sand available was taken from near the water/sand interface. Samples were collected in 1 gallon zip-lock plastic bags, double-bagged, and labeled by location and date. Some sample sites were photographed for future reference.

B) Sample Preparation: The samples were oven-dried for 24 hours at 32°C. Approximately 100 grams of each sample was then mechanically sieved in a series of progressively finer screens. Percentages of sand, silt and clay were established. (See Table 1.)

TABLE 1: PERCENTAGE OF SAND, SILT AND CLAY

Date	Site/Mile	Coarse sand		Medium sand		Fine sand		very fine sand		silt and clay	
		0	0.5	1	1.5	2	2.5	3	3.5	4	Pan
7/20/92	N. Canyon/20.6	13%	3%	3%	3%	4%	5%	10%	19%	12%	27%
7/20/92	Silver Grotto/29.2	4%	1%	1%	7%	12%	11%	14%	16%	9%	25%
7/21/92	Silver Grotto#2/29.2	27%	5%	7%	7%	6%	5%	6%	6%	4%	27%
7/21/92	Little Co./61.6	1%	1%	0%	2%	8%	11%	13%	21%	13%	31%
7/21/92	Little Co. #2/61.6	0%	0%	0%	0%	3%	16%	41%	24%	8%	8%
7/21/92	Carbon Creek/64.6	15%	1%	2%	3%	4%	7%	11%	14%	10%	34%
7/23/92	Bright Angel/87.8	3%	4%	7%	10%	10%	9%	12%	12%	8%	25%
7/23/92	Granite Falls/97.3	8%	2%	2%	3%	5%	6%	9%	13%	10%	43%
7/23/92	Shinumo Creek/106.7	7%	1%	3%	5%	10%	13%	23%	21%	7%	9%
7/23/92	Elve's Chasm/116.5	0%	0%	0%	0%	1%	2%	8%	24%	16%	48%
7/23/92	Blacktail Canyon/120	6%	2%	3%	3%	4%	5%	10%	17%	11%	39%
7/24/92	Forster Canyon/122.8	16%	1%	1%	2%	3%	5%	12%	21%	11%	28%
7/24/92	Deer Creek/136.3	0%	0%	1%	3%	8%	10%	16%	26%	16%	20%
7/25/92	Kanab Creek/143.4	13%	2%	3%	6%	6%	5%	8%	11%	7%	39%
7/25/92	Kanab Creek #2/143.4	15%	9%	11%	17%	13%	6%	5%	5%	3%	14%
7/25/92	Matkatamiba/147.8	15%	9%	10%	14%	15%	11%	11%	10%	3%	2%
7/25/92	Matkatamiba#2/147.8	0%	0%	0%	0%	0%	2%	13%	40%	20%	24%
7/25/92	Havasu Creek/156.8	3%	1%	2%	6%	10%	11%	13%	21%	10%	23%
7/26/92	National Canyon/166.5	0%	0%	0%	0%	1%	1%	4%	14%	13%	66%
7/27/92	194 Mile Canyon	2%	3%	15%	19%	14%	10%	9%	7%	3%	17%
7/28/92	220 Mile Canyon	1%	0%	0%	0%	0%	1%	4%	14%	20%	58%

FIGURE 1



1991 SAMPLE LOCATIONS

L. Colorado/61.4	SAMPLE 1
Carbon Creek/64.6	SAMPLE 2
Phantom Ranch/87.6	SAMPLE 3
Granite Rap/93.5	SAMPLE 4
Bass/108.8	SAMPLE 5
Shinumo/108.8	SAMPLE 6
Blacktail/120.1	SAMPLE 7
Forster Ck/122.8	SAMPLE 8
Deer Crk/136.3	SAMPLE 9
Kanab-mth/143.5	SAMPLE 10
Kanab-lwr/143.5	SAMPLE 11
Kanab-upr/143.5	SAMPLE 12
Nat'l-lwr/166.5	SAMPLE 13
Nat'l-200/166.5	SAMPLE 14
Nat'l-500/166.5	SAMPLE 15
Nat'l-mid/166.5	SAMPLE 16
M. 194-lwr/194	SAMPLE 17
M. 194-upr/194	SAMPLE 18
Granite Pk/204	SAMPLE 19

C) Gamma Ray Spectrometric Analysis: The samples will be analyzed for radioactive uranium and thorium. Natural radioactive gamma-ray spectra are measured for each sample using a shielded activated NaI crystal, photomultiplier tube and pulse analyzer. The spectra are then compared with the spectra from reference samples of known concentrations of uranium and thorium. The concentrations of uranium and thorium in the samples are computed from relative sizes of their energy peaks relative to the reference samples.

III. RESULTS

Results of this year's analysis are pending completion of gamma ray spectrometric analysis. Results of the 1991 analysis are shown in Figure 1. Of the 1989, 1990 and 1991 samples, higher-than-normal concentrations of uranium were found at Kanab Creek, National Canyon (Taylor, et al. 1989) and North Canyon (Bates, et al. 1990). The higher-than-normal samples were, respectively, 10.78 ppm U, 11.22 ppm U and 22.1 ppm U. All other uranium samples have been within normal range.

References:

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